

EPA Region 5 Records Ctr.



207534

TECHNICAL MEMORANDUM

**Soil Gas and Geophysical Investigation
of
Potential Source Area 7**

**Southeast Rockford
Groundwater Contamination Project**

August 1992

Prepared for:

**Illinois Environmental Protection Agency
Bureau of Land**

Prepared by:

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EPA/DLPC

Soil Gas and Geophysical Investigation
of
Potential Source Area 7

A combination of geophysical and soil gas techniques were used to define a potential source area for the VOC-contaminated groundwater plume in Southeast Rockford during May, 1992. The investigation discussed in this report consisted of a terrain conductivity survey, a ground-penetrating radar survey, and a soil gas survey, each of which were conducted on a grid established over the potential source area.

The suspected source area that was examined during this investigation was identified by review of historical aerial photos of the area and hydrogeologic data gathered during the first phase of the remedial investigation. The suspected source area is located east and southeast of Ekberg Park at the eastern terminus of Balsam Lane (Figure 1). USEPA performed a preliminary survey of the area using an EM-31 terrain conductivity meter on March 30, 1992, and determined that further investigation of the area is warranted because the conductivity survey indicated that buried metals may be present at the site. A more detailed investigation of the area was performed by Camp Dresser & McKee, USEPA's technical support group, and Tracer Research during May of 1992, and is the subject of this Technical Memorandum.

The study area examined during this investigation is referred to as Potential Source Area 7 in the Phase I Technical Memorandum. The investigation focused on two subareas within Potential Source Area 7. Fifty-foot square grids were laid out by professional surveyors over two areas where aerial photographs indicated disturbed soils and potential disposal areas. The disturbed soil areas, potential disposal areas identified from the photos, and the two gridded areas are illustrated in Figure 1. Together, these areas encompass approximately twelve acres.

Terrain Conductivity Survey

The terrain conductivity survey conducted at the site employed the induced electromagnetic coupling technique. The physical principal of induced electromagnetic coupling is well known. A vertical magnetic dipole is generated at the surface, which induces eddy currents in the ground with magnitude directly proportional to the ground conductivity. These currents induce a secondary magnetic dipole, which can be detected at the surface. The relative proportions of the primary magnetic field and the induced magnetic field can be used to derive an apparent ground conductivity.

The survey was conducted using a Geonics EM-31 Terrain Conductivity Meter. This instrument creates a primary magnetic dipole by passing an audio frequency alternating electrical current through a transmitter coil located on one end of the instrument. The induced magnetic field is detected through a receiver coil located at the opposite end of the instrument. The depth of penetration of the instrument is a function of the ground conductivity and the distance between the transmitter and the receiver coil. As a rule of thumb, the depth of penetration is generally on the order of the intercoil spacing, which is approximately 12 feet (3.7 meters) for the EM-31, although Geonics reports an effective depth of penetration of 20 feet (6 meters). Actual depth of penetration depends on site-specific variables such as soil resistivity and resistivity variation with depth.

The survey was conducted on May 26 to 28, 1992, by Rik Lantz and Troy Carlson of CDM. The survey was accomplished by running a series of east-west trending traverses, and recording conductivity values at five-foot intervals. The traverses were spaced 25 feet apart in the north-south direction.

Both the in-phase and out-of-phase (quadrature) components of the induced magnetic field were recorded at each station. The out-of-phase component of the total field is representative

of apparent terrain conductivity, whereas the in-phase component is more sensitive to large buried metal objects. The data were recorded in the field with an Omnidata Polycorder, and data were downloaded into a personal computer to form data files, and converted to a more convenient format using Geonics' DAT31 software, which was developed for that purpose.

The degree of the total induced magnetic field that is in- or out-of-phase depends on the ground conductivity. A medium with zero conductivity would generate an induced magnetic field that would be entirely out-of-phase with respect to the primary field, whereas a medium with infinite conductivity would generate an induced magnetic field perfectly in phase with the primary field. Because the conductivity of common geologic materials is seven to ten orders of magnitude lower than that of most metals, the electromagnetic response of large metallic objects is primarily observed on the in-phase channel and the response of normal geologic materials is primarily observed on the out-of-phase channel. A large number of small buried metallic objects such as cans and metal objects normally present in refuse would yield a moderately high conductivity measurement in the out-of-phase component and a highly variable in-phase component.

In order to ensure that the instrument was functioning properly, equipment functional checks and minor calibrations recommended by the manufacturer were performed each morning of the survey. In addition, conductivity was measured at a check location (center of the western basketball court) each morning. The quadrature component of the instrument drifted by approximately 0.8 millimhos/meter over the three days, indicating an instrument variation of approximately 6%, which was considered acceptable for the purposes of the survey.

The results of the survey are illustrated in Figures 2 through 5. Figures 2 and 3 illustrate the in-phase and out-of-phase components of terrain conductivity in the western portion of the study area. The figures display terrain conductivity anomalies that approximately coincide with the topographic depression labeled 'small valley' on Figure 1. The anomalous area consists of three linear features that extend from the southwest and southeast corners of the gridded area and from the basketball courts and join at the approximate location of grid point

250N 150E. This anomaly is evident in both the in-phase and out-of-phase components of the conductivity field, indicating that buried metal may be present.

An additional anomaly is located about 150 feet east of the basketball courts. This anomaly is unusual in that it is evident on five traverses that extend over a lateral distance of more than 100 feet, is symmetric about orthogonal axes, and is present only to a limited areal extent in the in-phase component of the conductivity field. This feature is of uncertain origin, but may represent a large buried metal object of some sort or two smaller buried metal objects. This anomaly merits further investigation in subsequent phases of the investigation.

The recorded terrain conductivity in the eastern portion of the study area is illustrated in Figures 4 and 5. The out-of-phase component of the conductivity field shows no major anomalies, but does exhibit a gradual increase in conductivity towards the southeast which is probably associated with variations in surface soil lithology. The small anomaly at 800N 1150E is associated with a hot water heater that was disposed of at that location. The in-phase component of the conductivity field shows no significant variation over the eastern gridded area.

Ground-Penetrating Radar Survey

The ground-penetrating radar (GPR) geophysical technique is similar to the seismic reflection technique, and involves generating a radar signal which is directed downward into the subsurface and detected at the surface by a mobile antenna. The time between when the radar signal is initiated and when it is received by the antenna can be used to estimate the depth to the reflector. Reflections that can be detected by the antenna are generated when the radar signal encounters variations in electrical permittivity or electrical conductivity of the medium the wave is passing through. Electrical permittivity is a frequency-dependent electrical property of soils that is a measure of polarizability.

Natural geologic conditions such as moisture, bedding, clay content, cementation, fractures, and voids are associated with changes in electrical conductivity and electrical permittivity, therefore an interface between two soil or rock layers with sufficient contrast in electrical properties will be visible on a radar profile. Metals also have electrical properties that are significantly different from soils, and can therefore be detected by the GPR method.

A GPR survey was performed over the southern portion of the study area on May 26 and 27, 1992 by Mark Vendl of USEPA's technical support group. The GPR system employed at this site used an 80 MHz antenna towed behind a small all-terrain vehicle. Effective depth of penetration of the antenna at the site was determined to be approximately 8 feet. The GPR device was towed in east-west and north-south traverses along the same grid used for the EM-31 survey, and results were recorded on a burned-paper facsimile recorder. The resulting records were then interpreted by Mark Vendl, and anomalous areas were identified and plotted on the site grid. USEPA's GPR survey of the site is discussed in greater detail in the Technical Memorandum included with this report as Appendix A.

A Y-shaped area of disturbed soils that roughly coincides with the gentle topographic valley in the study area was interpreted from the GPR survey (Figure 6). Areas of disturbed soils extend from both the southeast and southwest corners of the grid, meet, and then trend to the north-northwest off of the gridded area. The GPR survey was continued west of the gridded area, and a linear swath of disturbed soils extending to the area between the basketball and tennis courts was identified. No GPR anomalies were identified near the former gravel pit or over the other disturbed areas identified from the aerial photos.

Several east-west-trending GPR traverses were run over the eastern gridded area (near O'Connell Street), and no anomalies were identified.

Soil Gas Survey

A soil gas survey was performed across the gridded areas by Tracer Research of Tucson, Arizona from May 26 to 29, 1992. The soil gas technique employed at the site involves driving a soil gas probe to a specified depth below the surface, extracting a sample of soil gas from that depth, and analyzing the sample using a field gas chromatograph. Soil gas samples were collected from 78 locations at depths of seven feet below grade except at eight of the sampling locations where subsurface obstructions required that samples be collected from shallower depths. Samples were analyzed for tetrachloroethene (PCE), 1,1,1-trichloroethane (TCA), and trichloroethylene (TCE). The soil gas survey is discussed in detail in the summary report prepared by Tracer, which is included with this report as Appendix B.

Results of the soil gas survey are presented in Figures 7 through 10. The figures illustrate only the western area because no significant soil gas anomalies were discovered in the eastern gridded area. Soil gas results for the eastern gridded area are included in Appendix B.

Tetrachloroethene (PCE) concentrations in soil gas are illustrated in Figure 7. Soil gas contamination by PCE was detected at various concentrations across the entire study area, at levels up to 1,100 $\mu\text{g/L}$. The soil gas samples with the highest degree of contamination are aligned along an axis oriented roughly north-south through the basketball court, and extending from the top to the bottom of the study area. The region of high contamination splits and extends to the southeast at the location of the highest concentration of contaminants (approximately 350N 50E).

1,1,1-Trichloroethane (TCA) concentrations in soil gas are illustrated in Figure 8. The distribution of TCA in soil gas is essentially the same as that of PCE, but TCA concentrations were higher than PCE concentrations, ranging up to 3,800 $\mu\text{g/L}$.

Trichloroethylene (TCE) concentrations in soil gas are illustrated in Figure 9. TCE distribution in soil gas followed the same general pattern as the observed distribution for PCE and TCA, but the affected area was more restricted than that of the other parameters. No TCE was detected over much of the northeastern part of the western gridded area. Soil gas TCE concentrations ranged up to 690 $\mu\text{g/L}$, and were in general lower than those of PCE and TCA.

A map showing the sum of the concentrations of the three VOCs tested for (TCA, PCE, and TCE) shows essentially the same distribution as the three individual VOCs (Figure 10). The area of highest contamination extends along a north-south axis running through the tennis and basketball courts along the western margin of the grid. The highest soil gas concentrations were encountered at grid location 350N 50E, and an area of moderate contamination (10 to 100 $\mu\text{g/L}$) extends to the southeast along the topographic depression. The overall contaminated area forms a broad, diffuse Y-shaped anomaly that roughly coincides with the geophysical anomalies.

The areal extent of the soil gas anomalies is limited by background or near-background concentrations in soil gas samples collected over much of the study area. Low concentrations in soil gas samples collected to the west of the gridded area and along the northern, eastern, and southern perimeter of the grid indicate that the soil gas anomalies do not extend beyond these locations.

In contrast, the soil gas anomalies appear to extend beyond the grid in the northwest and southwest corners of the study area. For example, the soil gas sample from grid location 50S 50E was contaminated with PCE and 1,1,1-TCA at concentrations of 170 $\mu\text{g/L}$ and 150 $\mu\text{g/L}$, respectively, suggesting that soil gas concentrations to the southwest of this location would also exhibit elevated solvent concentrations. The relatively high concentrations of soil gas in samples collected near the northwest and southwest corners of the gridded area imply that the soil gas anomalies extend beyond the edge of the grid at these locations.

Preliminary calculations indicate that the observed solvent concentrations in soil gas correspond to parts-per-million concentrations in soil. Solvent concentrations in soil can be roughly estimated from solvent concentrations in soil gas by using the following expression:

$$C_s = \frac{C_g f_{oc} K_{oc} T R}{H}$$

where:

- C_s = concentration in soil (mg/kg)
- C_g = concentration in soil gas (mg/L)
- f_{oc} = weight fraction of organic carbon in soil (dimensionless)
- K_{oc} = octanol-water partition coefficient or soil sorption coefficient (L/kg)
- T = temperature (°K)
- R = gas constant = 8.2×10^{-5} atm m³ / mol °K
- H = Henry's Law constant (atm m³ / mol)

Estimated maximum solvent concentrations in soil were derived using the above equation and estimated constants, literature-derived constants, and maximum soil gas concentrations reported by Tracer Research. The weight fraction of organic carbon (f_{oc}) in site soils was estimated to be 0.5% based on values published by Schwarzenbach and Westall (1981). This f_{oc} value lies within the range of measured organic carbon values for samples of aquifer material from the site. Numerical values for K_{oc} and H were taken from Schwille (1988). Soil temperature was assumed to be 283 °K (10 °C).

Resulting estimated maximum soil solvent concentrations are presented in Table 1. The soil solvent concentrations reported here are estimated values, and should be regarded as first-order approximations. Calculations used to derive these values are included with this

report as Appendix C. Actual soil solvent concentrations may vary from the values listed, and should be determined by laboratory analysis of soil samples collected from the affected areas.

Table 1: Maximum Estimated Soil Solvent Concentrations

<u>Compound</u>	<u>K_{oc}</u>	<u>H</u>	<u>Max. Reported Soil Gas Concentration</u>	<u>Estimated Max. Solvent Concentration in Soil</u>
TCA	152 L/kg	0.0130 atm m ³ /mol	3,800 µg/L	5.2 mg/kg
PCE	364 L/kg	0.0131 atm m ³ /mol	1,100 µg/L	3.6 mg/kg
TCE	126 L/kg	0.0071 atm m ³ /mol	690 µg/L	1.4 mg/kg

Estimated maximum soil solvent concentrations of 5.2, 3.6, and 1.4 ppm were calculated for TCA, PCE, and TCE, respectively (Table 1). If soil solvent concentrations in the parts per million range are in fact present at the site, it is likely that Potential Source Area 7 is an ongoing source of contamination.

Summary and Conclusions

The three techniques used in this investigation have defined a shallow soil-covered Y-shaped trench filled with refuse. The geophysical techniques described in this report have defined a distinct Y-shaped anomaly, and the soil gas survey defined a more diffuse area of soil contamination with a similar shape (Figure 11). The close association of a large soil gas anomaly with the anomalies defined by the geophysical surveys suggests that the disturbed soils and buried refuse in the Y-shaped trench are a source area. Although the northwestern portion of the anomaly appears to contain the highest soil gas solvent concentrations, the area of soil gas contamination extends 200 to 300 feet southeast and southwest beyond the point where the linear geophysical anomalies meet.

There was good agreement among the anomalies defined by the three techniques, but the soil gas anomaly was located a short distance to the west of the geophysical anomalies, suggesting that minor migration of the solvents may be occurring, that the solvents were disposed of in the area to the west of the depression, or that the soil gas grid spacing was too coarse to discern the detailed structure of the soil gas plume. Although the Y-shaped anomalous area was identifiable on aerial photographs, the major areas of surficial disturbance shown on air photos do not coincide with geophysical or soil gas anomalies. These observations suggest that disposal of wastes and solvents in and near a topographic depression overgrown with brush and trees resulted in a contamination source that was later filled in with native soils.

As a result of this investigation, the following conclusions have been reached:

- 1) The three techniques employed at the site have defined anomalous areas that are in general agreement, but differ from one another depending on the technique used. There is good agreement between the GPR anomaly and the terrain resistivity anomaly, with the exception that the protrusion on the southeastern leg of the EM-31 anomaly was not reflected in the GPR survey. The EM anomaly centered at 500N 250E was not observed in the GPR survey because the GPR traverses did not cover the area including the anomaly.
- 2) The soil gas survey defined a large north-south trending anomaly which roughly coincides with the western portions of the EM-31 and GPR anomalies. The soil gas anomaly is more diffuse than the geophysical anomalies, and is centered approximately 50 feet west of the anomalies defined by the geophysical methods. No soil gas anomaly was associated with the EM-31 anomaly at grid location 500N 250E, but the closest soil gas survey point was approximately 25 feet removed from the center of the EM anomaly.

- 3) The use of the combined geophysical and soil gas methods allowed a substantial reduction in the size of the potential source area and aided identification of 'hot-spots' for remedial action. The geophysical surveys delineated areas of disturbed soils in addition to the area affected by VOC contamination. These disturbed areas should be further investigated to determine if contaminants other than VOCs have been improperly disposed of at these locations.
- 4) The soil gas and geophysical anomalies mapped during this investigation appear to extend beyond the southwest and northwest corners of the western gridded area. Future investigation of the suspected source area should focus on further delineating the extent of contamination in the area west and northwest of the tennis and basketball courts and in the wooded area southwest of grid location 0N 0E. In addition, future investigation of the nature of the smaller EM anomaly centered at grid location 500N 250E is merited.
- 5) Preliminary calculations suggest that soils in the vicinity of the anomalies are contaminated with solvents at the low parts-per-million level. If so, these soils may be a continuing source of groundwater contamination. This hypothesis should be confirmed by drilling additional soil borings and performing laboratory analysis of soil samples.

CDM recommends that Potential Source Area 7 be further investigated as a potential contaminant source. Soil samples should be collected from the high concentration portions of the soil gas anomalies to confirm the estimated solvent concentrations in soils and to evaluate the need for remedial action. Additionally, the soil gas and geophysics grid should be extended to the area northwest of the basketball courts and southwest of the western grid in order to determine the full extent of the soil gas and geophysical anomalies.

References

Schwarzenbach, R. P., and J. Westall, 1982, Transport of Nonpolar Organic Compounds from Surface Water to Groundwater: Laboratory Sorption Studies, Environmental Science and Technology, Vol. 15, No. 11.

Schwille, F., 1988, Dense Chlorinated Solvents in Porous and Fractured Media: Model Experiments, Lewis Publishers, Inc., Chelsea, Michigan, 146 p.

Appendix A

Ground-Penetrating Radar Survey Report

by:

USEPA Technical Support Group

Appendix B

Soil Gas Survey Report

by:

Tracer Research Corporation

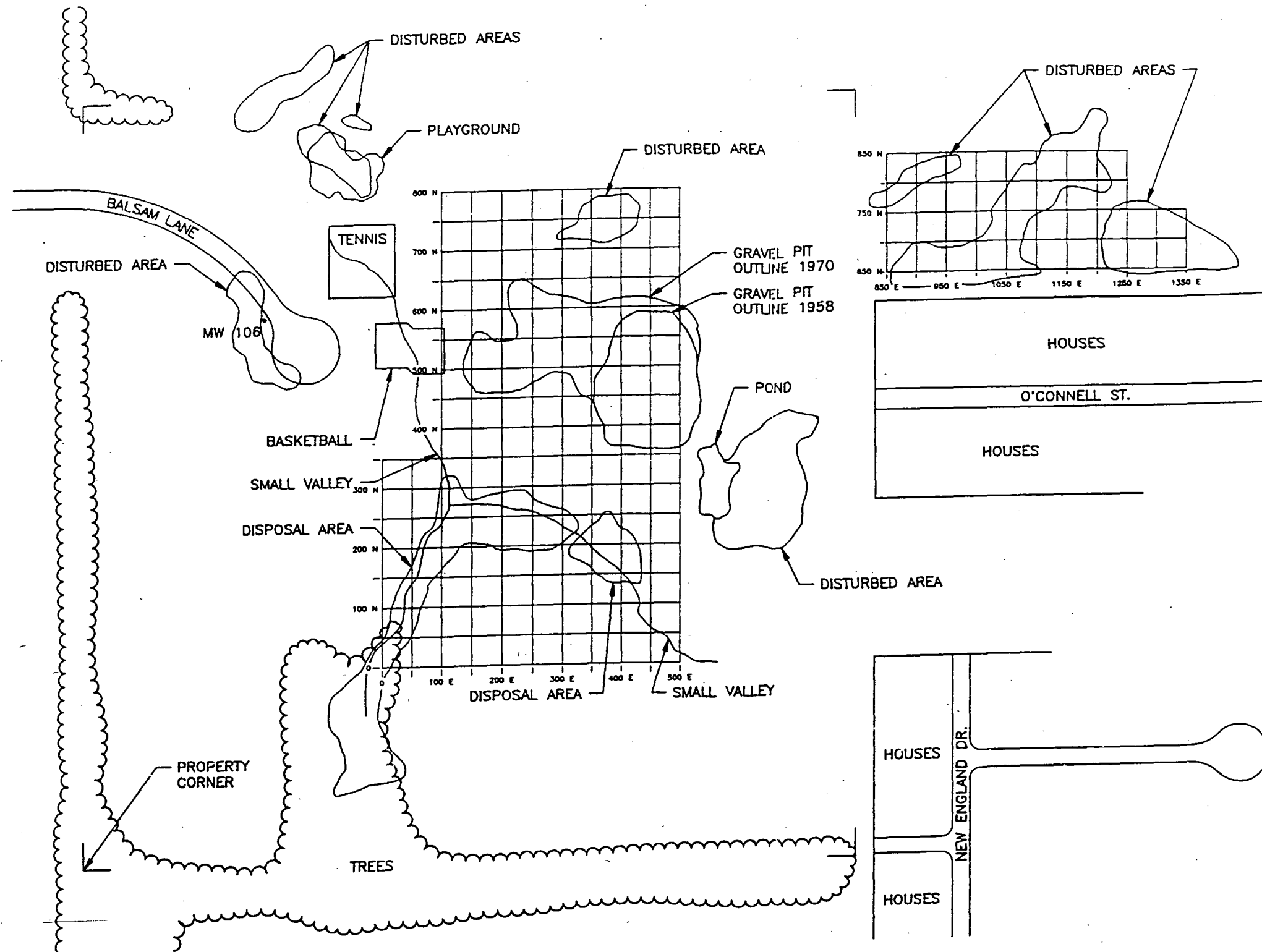
Appendix C

Calculations Used to Derive Solvent Concentrations in Soil

09/18/92 G. FOSZCZ

FIG1

D:\1681\7\N\PLN\



LEGEND:

- CURRENT FEATURES
- PAST DISPOSAL AREAS AND OTHER FEATURES
- SURVEY GRID POINT

SOUTHEAST ROCKFORD GROUNDWATER CONTAMINATION STUDY
POTENTIAL SOURCE AREA 7

CURRENT AND PAST FEATURES, AND SURVEY GRID

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Figure No. 1

09/18/92 G. FOSZCZ

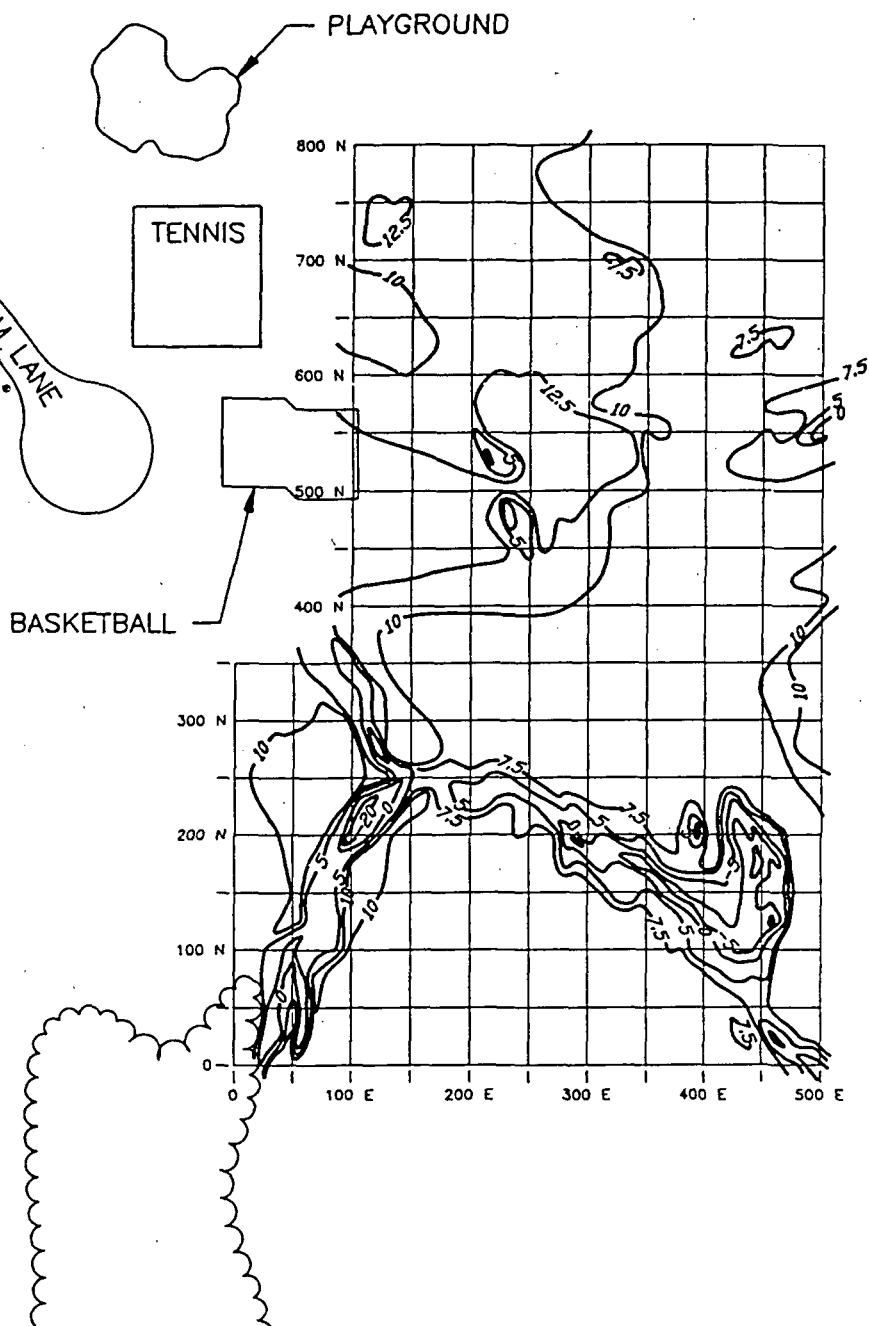
FIG 2

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LEGEND

—7.5— TERRAIN CONDUCTIVITY
(In millimhos/m)

SCALE
50 0 100



SOUTHEAST ROCKFORD GROUNDWATER CONTAMINATION STUDY
POTENTIAL SOURCE AREA 7

TERRAIN CONDUCTIVITY IN WESTERN GRIDDED AREA
OUT-OF-PHASE COMPONENT

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Figure No. 2

09/18/92 G. FOSZCZ

FIG 3

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LEGEND

— 10 — TERRAIN CONDUCTIVITY
(In millimhos/m)

SCALE
50 0 100

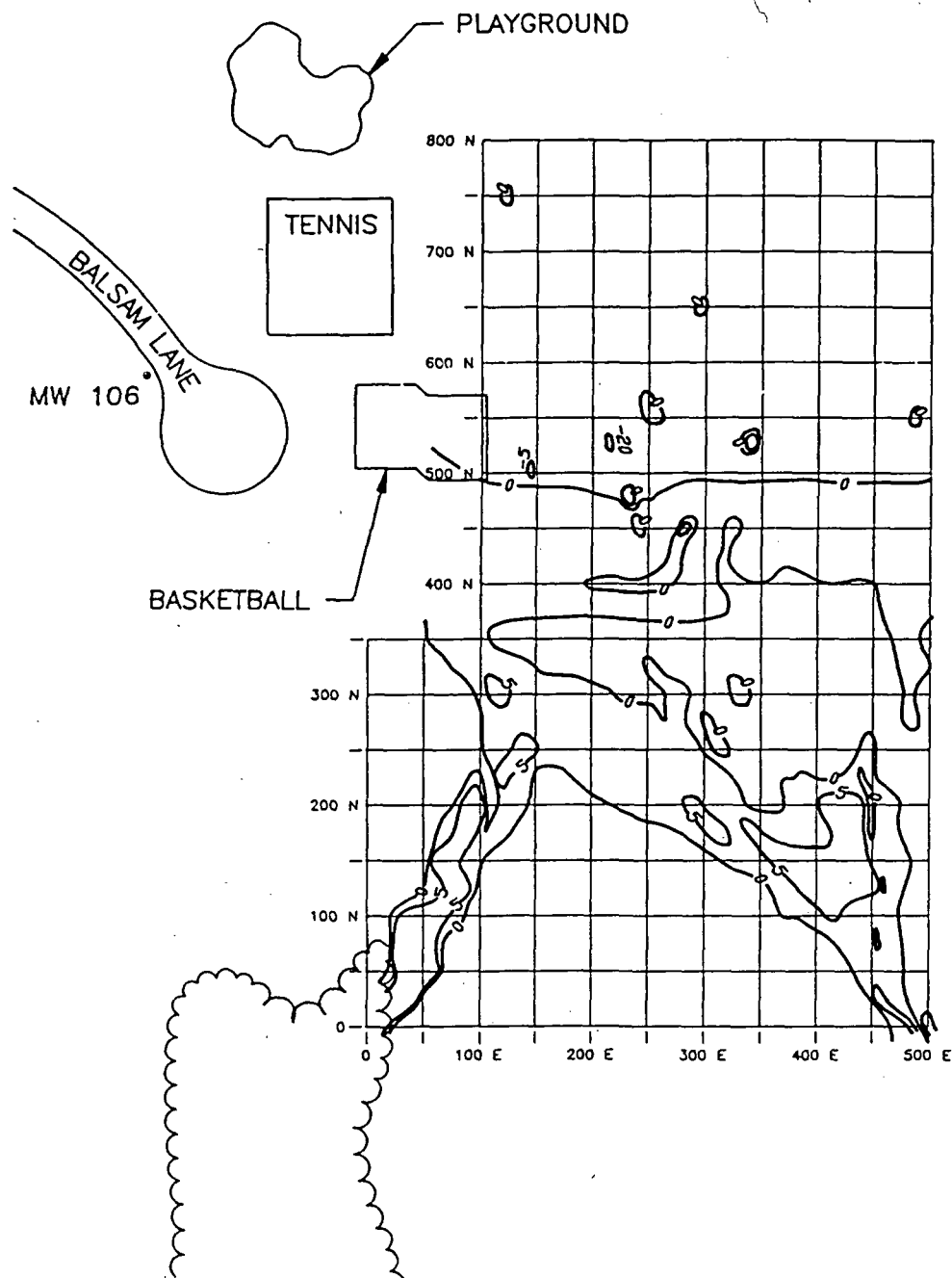
SOUTHEAST ROCKFORD GROUNDWATER CONTAMINATION STUDY
POTENTIAL SOURCE AREA 7

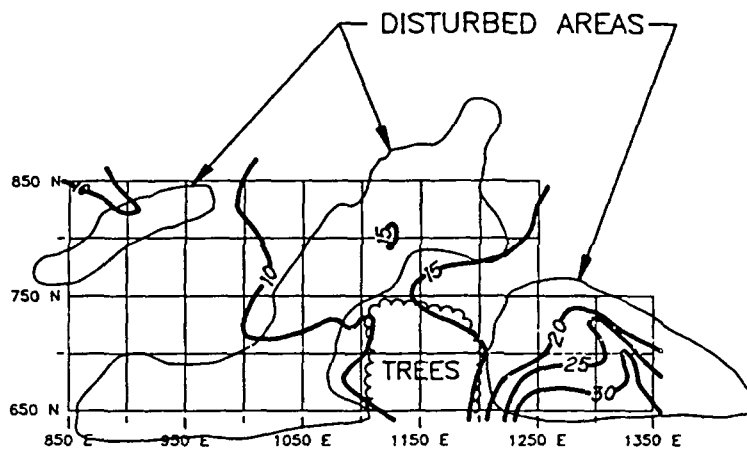
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TERRAIN CONDUCTIVITY IN WESTERN GRIDDED AREA
IN-PHASE COMPONENT

Figure No. 3





LEGEND

— 10 — TERRAIN CONDUCTIVITY
(In millimhos/m)

SCALE

50 0 100

SOUTHEAST ROCKFORD GROUNDWATER CONTAMINATION STUDY
POTENTIAL SOURCE AREA 7

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TERRAIN CONDUCTIVITY IN EASTERN GRIDDED AREA
OUT-OF-PHASE COMPONENT

Figure No. 4

09/18/92 G. FOSZCZ

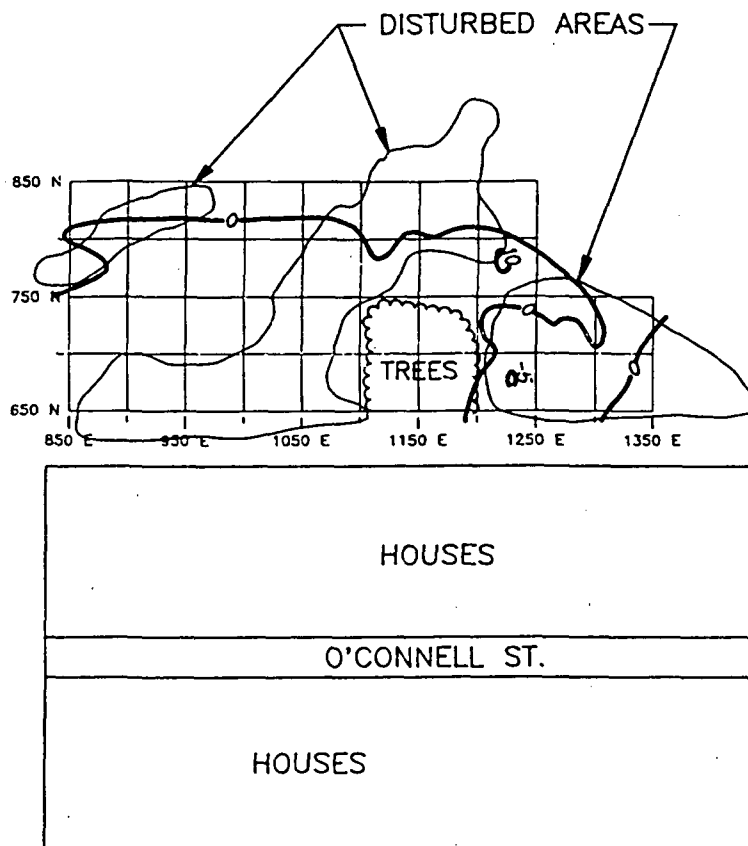
FIG4

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09/18/92 G. FOSZCZ

FIG 5

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LEGEND

— 10 — TERRAIN CONDUCTIVITY
(In millimhos/m)

SCALE

50 0 100

SOUTHEAST ROCKFORD GROUNDWATER CONTAMINATION STUDY
POTENTIAL SOURCE AREA 7

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TERRAIN CONDUCTIVITY IN EASTERN GRIDDED AREA
IN-PHASE COMPONENT

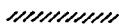
Figure No. 5

09/18/92 G. FOSZCZ

FIG 6

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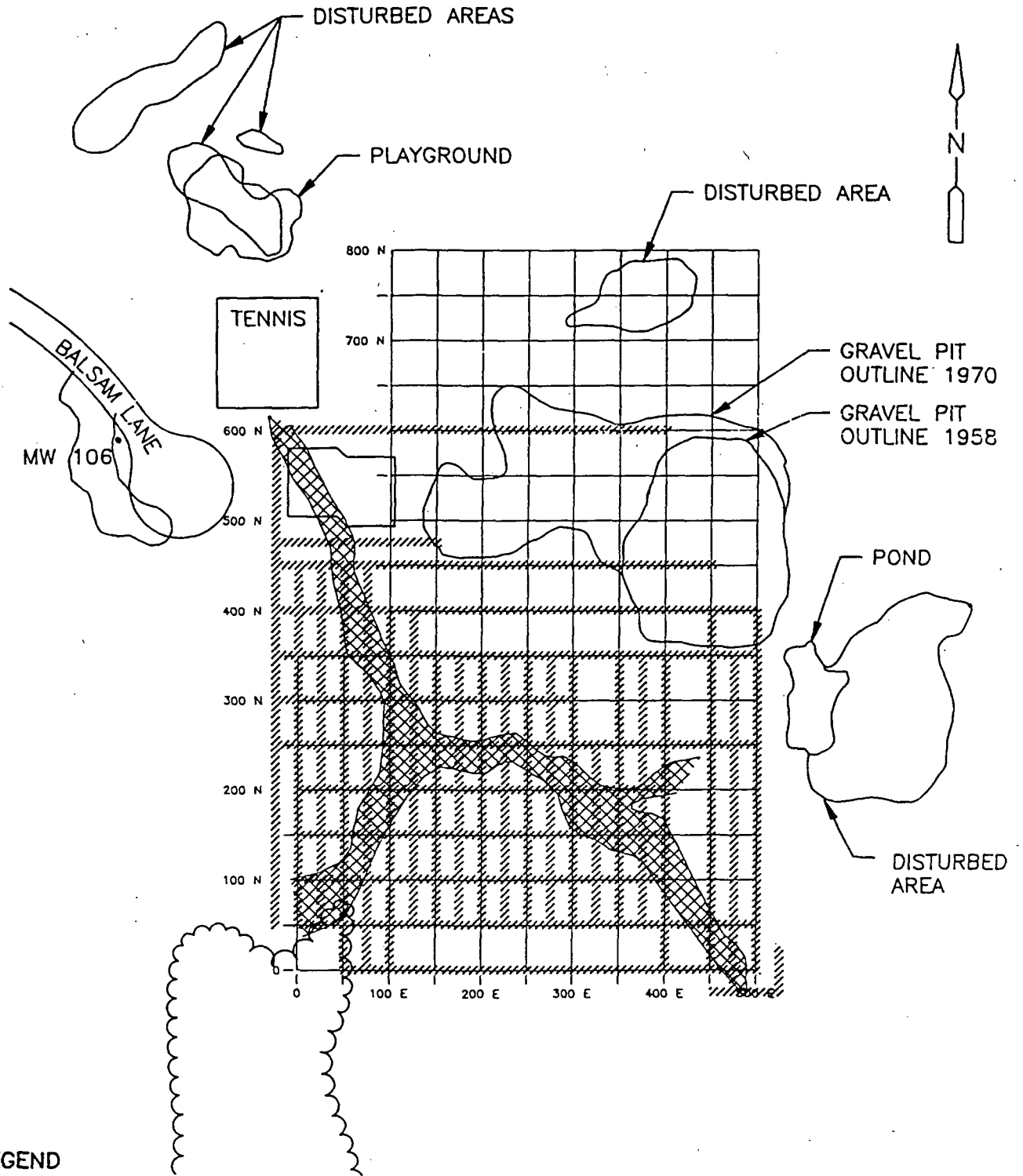
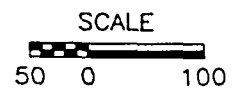
LEGEND



GPR SURVEY TRAVERSE



DISTURBED SOIL DETECTED BY
GROUND PENETRATING RADAR



SOUTHEAST ROCKFORD GROUNDWATER CONTAMINATION STUDY
POTENTIAL SOURCE AREA 7

GROUND PENETRATING RADAR SURVEY
MAY 26-27, 1992

CDM

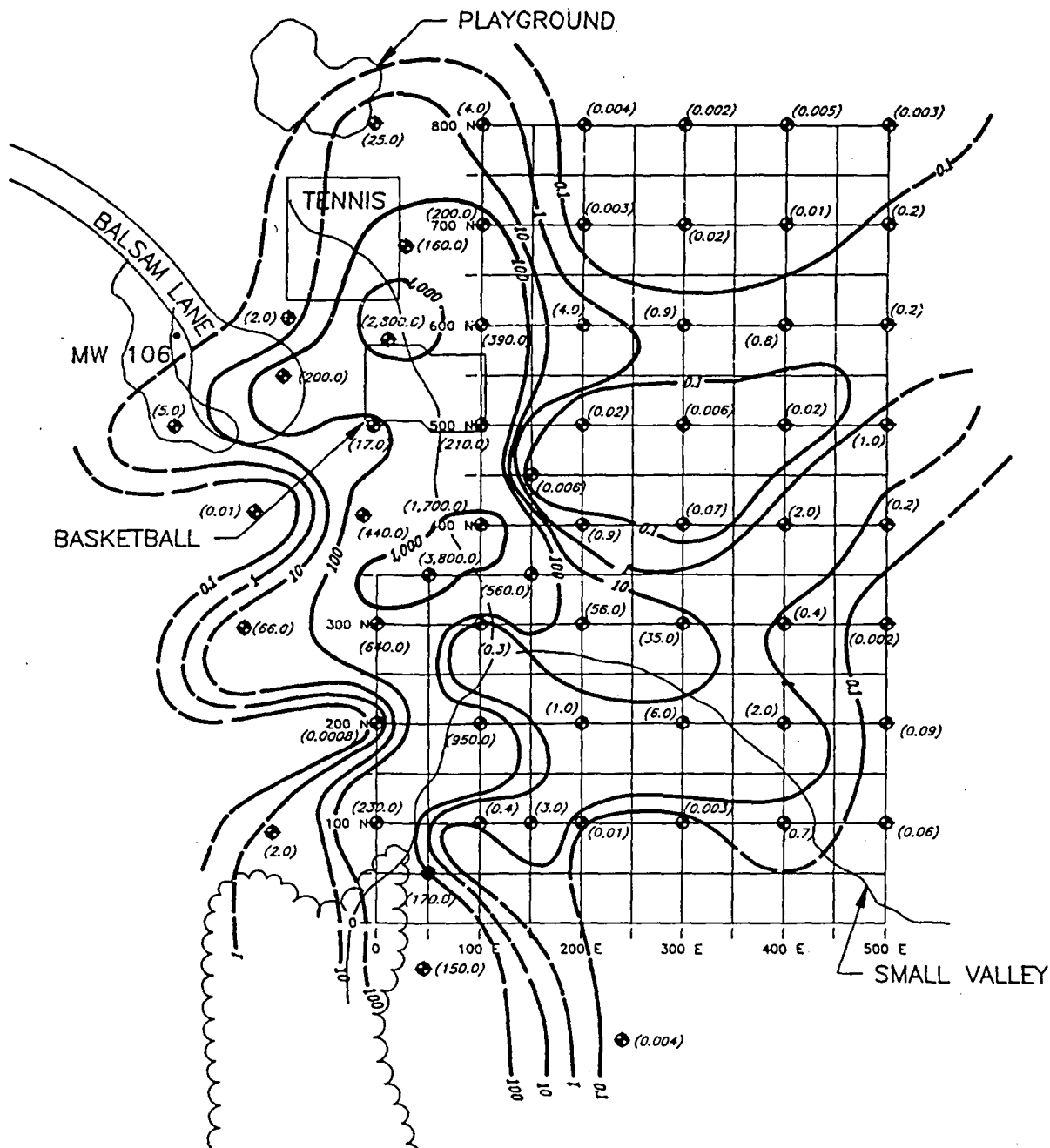
environmental engineers, scientists,
planners, & management consultants

Figure No. 6

09/18/92 G. FOSZCZ

FIG 8

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SOUTHEAST ROCKFORD GROUNDWATER CONTAMINATION STUDY
POTENTIAL SOURCE AREA 7

1,1,1-TCA CONCENTRATION IN
SOIL GAS

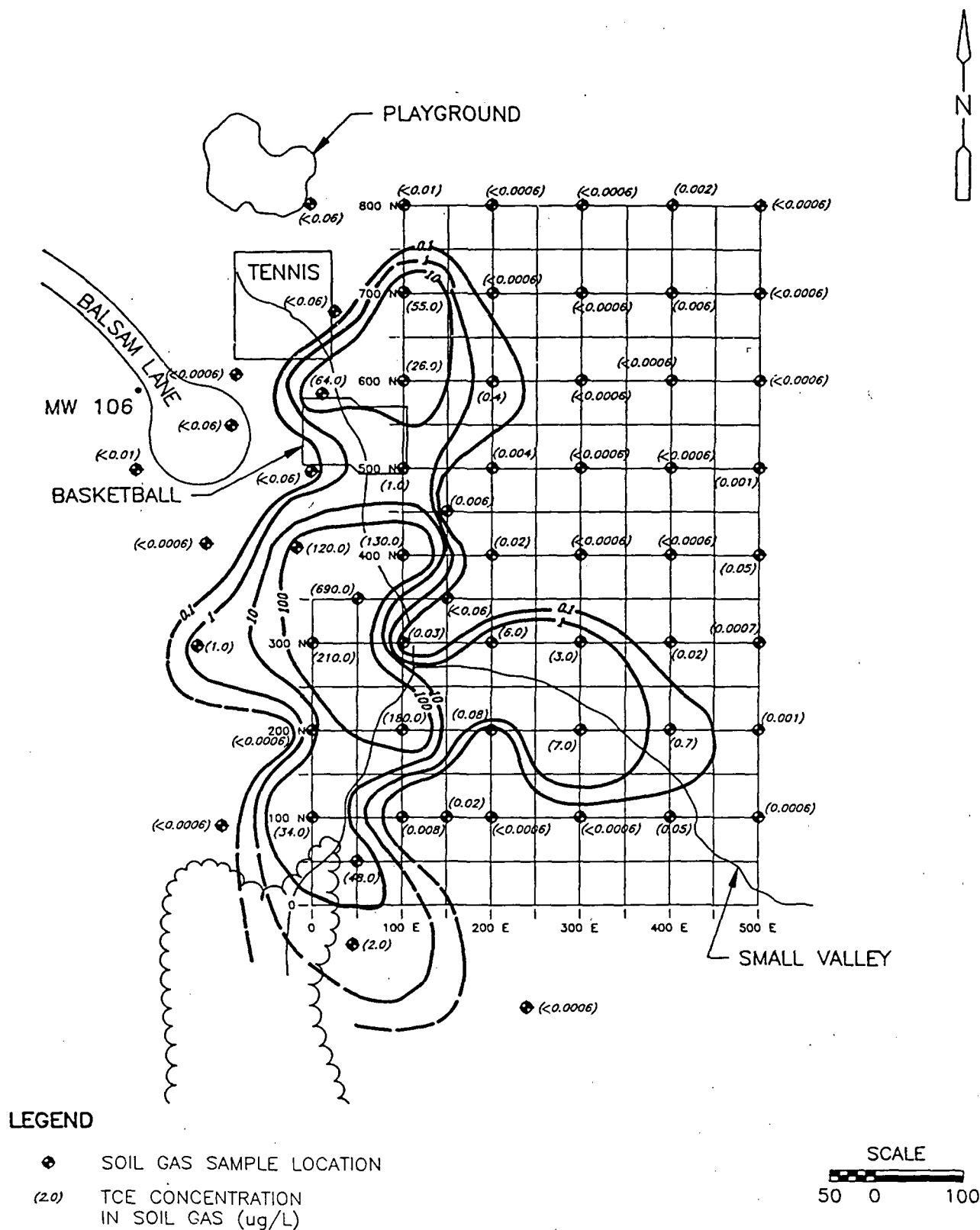
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Figure No. 8

09/18/92 G. FOSZCZ

FIG9

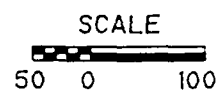
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SOUTHEAST ROCKFORD GROUNDWATER CONTAMINATION STUDY
POTENTIAL SOURCE AREA 7
TCE CONTAMINATION IN
SOIL GAS

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Figure No. 9



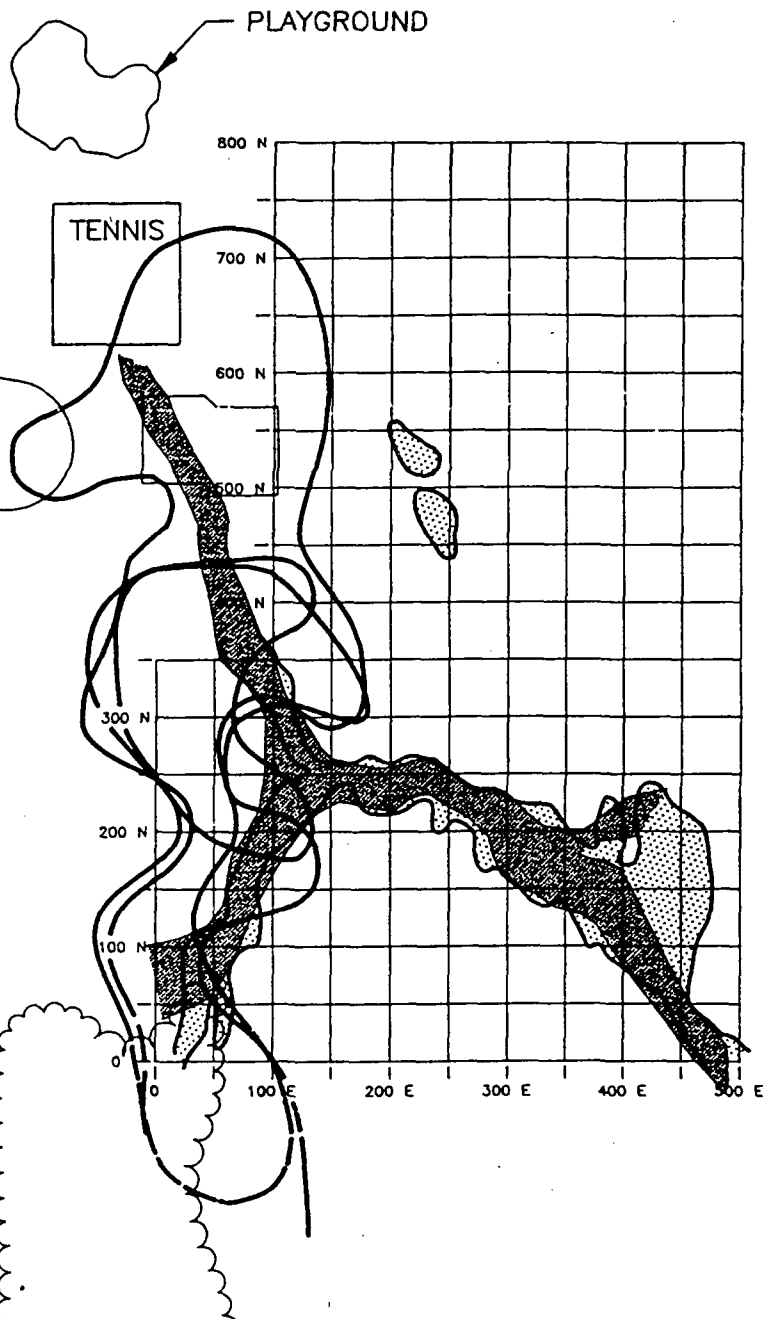
9/22/92 K. HRECZUCH

FIG 11

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LEGEND

- SOIL GAS ANOMALY (>100 ug/l)
- EM-31 ANOMALY
- GPR ANOMALY



SOUTHEAST ROCKFORD GROUNDWATER CONTAMINATION STUDY
POTENTIAL SOURCE AREA 7

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AREAL VIEW OF SOIL GAS AND GEOPHYSICAL ANOMALIES

Figure No. 11

Appendix A

Ground-Penetrating Radar Survey Report

by:

USEPA Technical Support Group

United States
Environmental Protection
Agency

Region 5
Waste Management Division
77 West Jackson Blvd.
Chicago, Illinois 60604

TECHNICAL SUPPORT SECTION



Southeast Rockford Rockford, Illinois

Ground Penetrating
Radar Survey

May 26-27, 1992

**Technical Memorandum
Southeast Rockford Ground Water Contamination Site
Rockford, Illinois**

**Ground Penetrating Radar Survey
May 26-27, 1992**

**Mark Vendl
Office Of Superfund
Region V
U.S. Environmental Protection Agency
Chicago, Illinois**

**Final Report
July, 1992**

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1.0 INTRODUCTION

At the request of Karen Vendl, Remedial Project Manager in the Illinois/Indiana Branch, Office of Superfund, Region V, U.S. Environmental Protection Agency (USEPA), a ground penetrating radar (GPR) survey was conducted at the Southeast Rockford Ground Water Contamination Site, Rockford, Illinois on May 26-27, 1992 by Mark Vendl, Geologist, Technical Support Section, Office of Superfund, Region V, USEPA.

1.1 Background and History

Ground water sampling programs by the Illinois Department of Public Health (IDPH), the Illinois Environmental Protection Agency (IEPA) and the USEPA have established that a major ground water contamination problem exists in the south east section of Rockford, Illinois. Studies have shown that a plume of volatile organic compound (VOC) contaminated ground water traverses an area where local residents rely on well water for a potable water source. USEPA and IEPA are currently involved in a joint effort to study this problem and evaluate possible remedies.

The study area is located near Southeast Rockford in Winnebago County, and consists of approximately 2.4 square miles in Sections 1, 2, 3, T43N, R1E, and Section 6, T43N, R2E. The study area is bounded by Harrison Avenue to the North, Sandy Hollow Road to the South, the north-south center line of Section 6 to the East, and

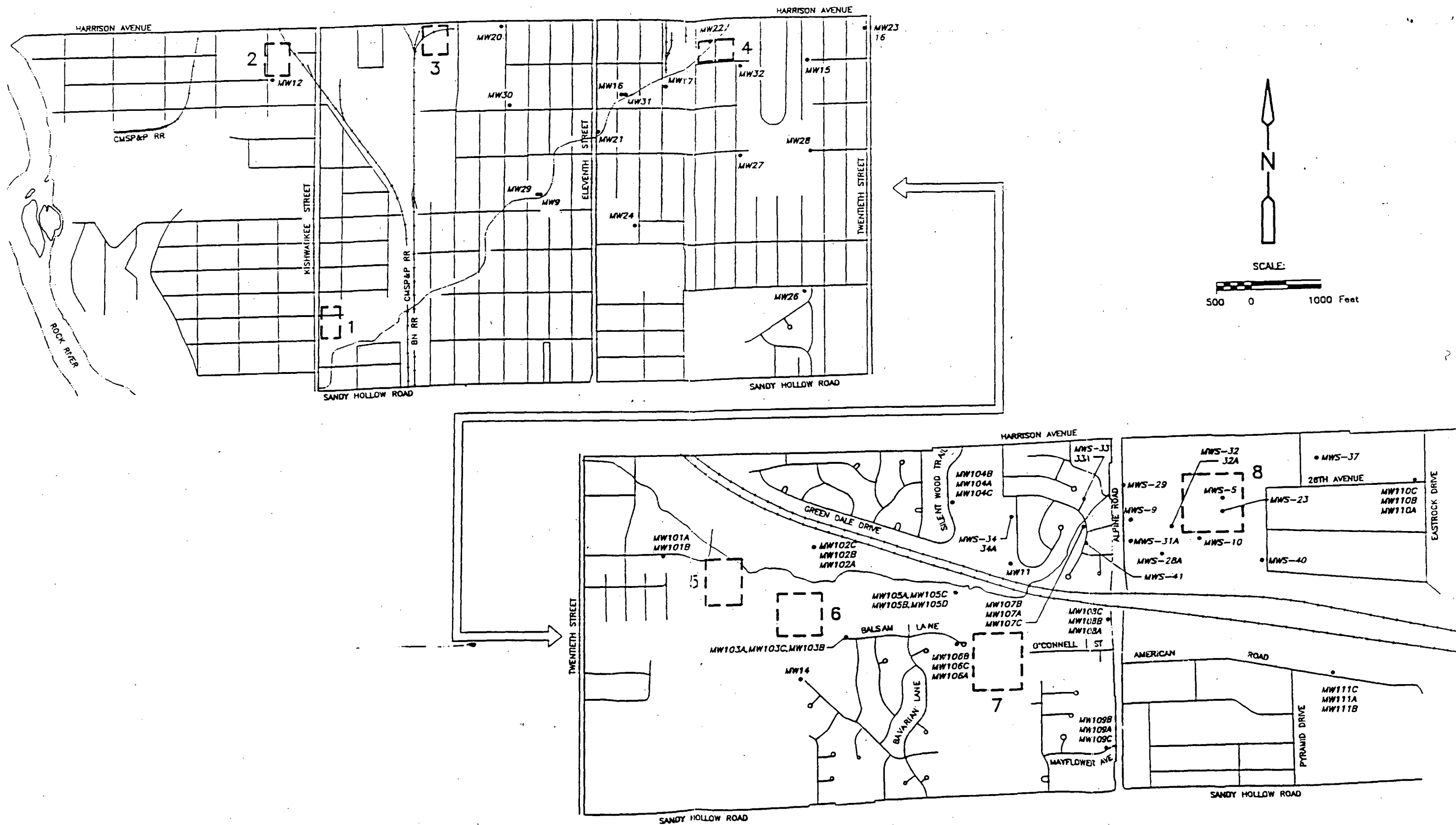
the Rock River to the West (Figure 1).

The study area is predominantly an urban area, which includes scattered industrial, retail, and commercial operations. A small industrial park is located near the eastern edge of the study area in the vicinity of Laude Drive. Other industrial areas are situated in the vicinity of Harrison Street and Eighth Street, near the Rock River in the northwest part of the study area, and elsewhere in the study area.

The local geology of the study area consists of a valley-train deposit that fills an eroded pre-glacial drainageway. The valley-train deposit forms a wedge of unconsolidated sand and gravel deposits that are interbedded with laterally discontinuous clay- and silt-rich strata. These unconsolidated sediments unconformably overlie the Galena-Platteville Group or the St. Peter Sandstone, the latter of which is an important aquifer in northern Illinois.

Ground water contamination by volatile organic compounds (VOCs) was initially discovered in the study area by the City of Rockford in 1981. Four municipal wells in Southeast Rockford were taken out of service in December 1981 as a result of the contamination. Contamination of Municipal Well 35 was discovered during a routine sampling of the well in 1984, and the well was taken out of service in 1985.

As a result of sampling events by state and federal agencies, the Southeast Rockford



SOUTHEAST ROCKFORD

Figure 1. Site Location Map.

Ground Water Contamination Site was proposed for inclusion on the National Priorities List (NPL) in March 1989 as a state-lead, federally funded Superfund site. Response actions by the USEPA in 1990 and 1991 provided city water to 548 residences with private wells contaminated with VOCs greater than Maximum Contaminant Levels. With these actions, the public health threat, as it existed at the time, has been eliminated (Camp Dresser & McKee Inc., 1990).

IEPA is currently conducting a multi-phase remedial investigation/feasibility study of the plume to characterize the nature and extent of the contamination, and to address the long-term remediation of the contamination problem.

This GPR study came about as a result of the draft IEPA Phase I remedial investigation report, as well as citizen complaints. The draft report indicated that an area west of O'Connell Street and east of Balsam Lane (identified in the Phase I RI as "Area 7) is a likely source of contamination. This conclusion was made based on an evaluation of the analytical results of the monitoring well samples that were taken from MW 106, 108, and 109. In addition, USEPA received reports that illegal dumping had occurred in Area 7 in past years.

On March 30, 1992, representatives of USEPA joined by a representative of IEPA conducted a cursory geophysical survey of both Area 7 and Area 6 (to the west of Area 7). The survey was conducted using a Geonics Model EM31 ground

conductivity meter. In Area 6, only 2 or 3 isolated "spots" of buried metal were located. However, at Area 7, a large area of buried metal was located. It was because of this finding in Area 7 that the GPR study was initiated to further locate and map this anomaly.

1.2 Objectives

The objective of this survey was to locate and map any waste fill areas that could be the source of ground water contamination seen in MW #106.

2.0 PROCEDURES

2.1 GPR Geophysics

GPR uses high frequency electromagnetic waves (from less than 50 MHz to more than 1,000 MHz) to acquire subsurface information. Energy is radiated downward into the ground from a transmitter antenna, is reflected from buried objects that have different electrical properties from the surrounding ground, and is detected at a receiver antenna. The reflected signals are recorded and produce a continuous cross-sectional picture or profile of shallow subsurface conditions. The basic components of a GPR system are illustrated in Figure 2.

Reflections of radar waves occur whenever there is a change in the dielectric

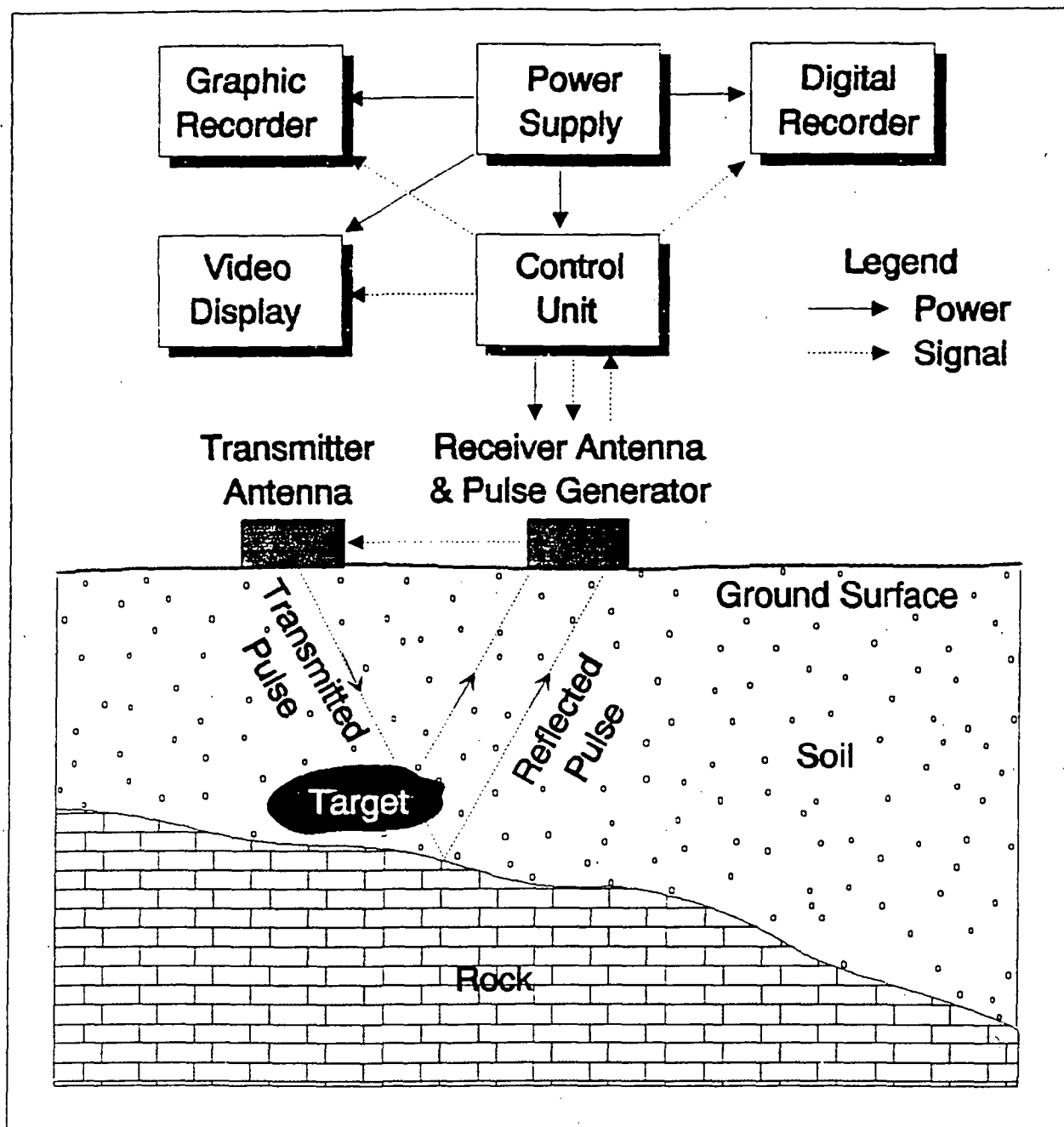
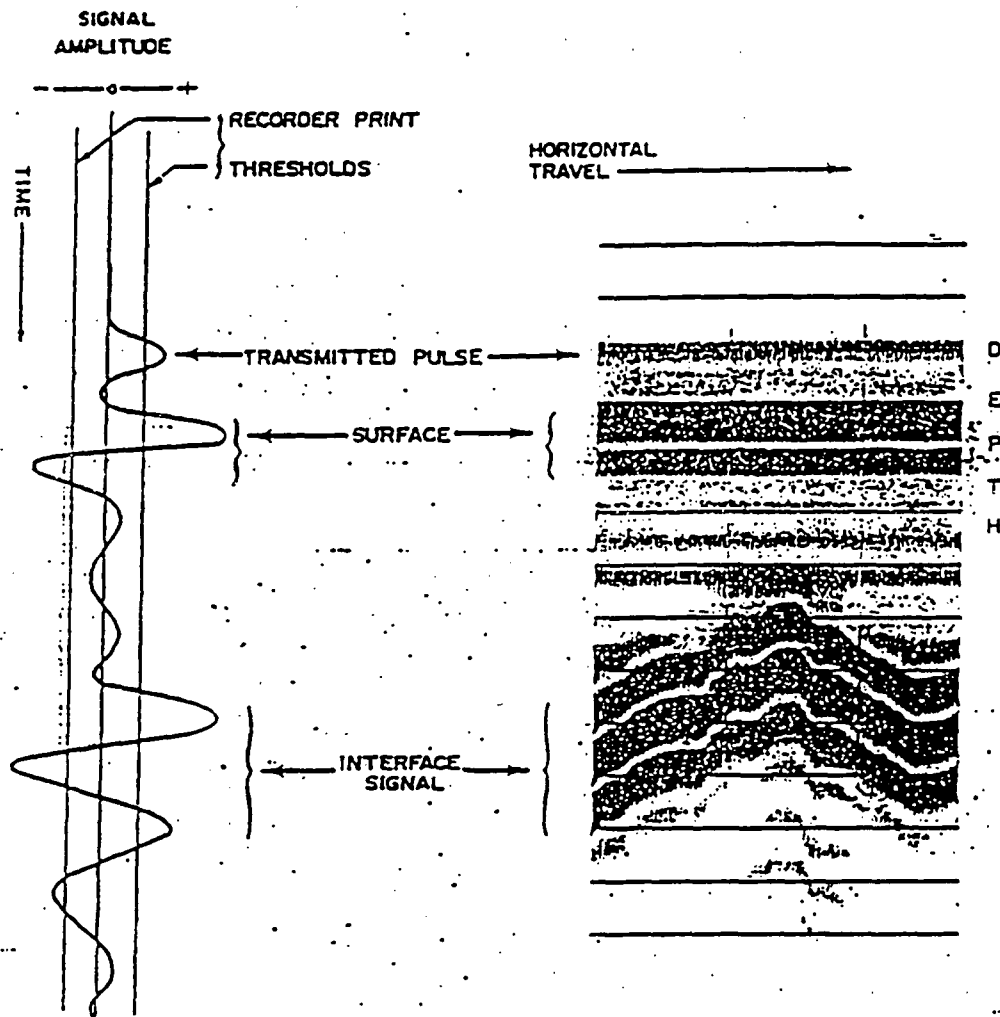


Figure 2 Schematic Diagram of a Ground Penetrating Radar System

permittivity or electrical conductivity between two materials. Changes in electrical properties are associated with natural geologic and/or hydrogeologic conditions such as bedding, cementation, moisture, clay content, voids, and fractures, as well as man-made objects. Therefore, an interface between two soil or rock layers which has sufficient contrast in electrical properties will show up in the radar profile.

GPR data are commonly displayed in variable density format. Figure 3 shows how a variable density record is constructed. Each reflection arrival is gray-shaded proportional to the amplitude of the arrival. The highest amplitude is shaded the darkest while amplitudes below a defined threshold level are left unshaded. Since scans are made rapidly with respect to the velocity at which the antenna is moved over the ground surface, the GPR method is referred to as a continuous subsurface profiling method.

The vertical scale of the radar profile is in units of two-way travel time, the time it takes for an electromagnetic wave to move down to a reflector and back to the surface. The unit of time is nanoseconds ($1 \text{ ns} = 10^{-9} \text{ second}$). This time is relatively short because the waves are traveling at almost the speed of light. The travel time is then converted to depth by relating it to measurements or assumptions about the velocity of the waves in the subsurface materials.



a) Sketch of a single Pulse and Reflections as seen by the receiver

b) Example of Profile Information as Displayed by the Graphic Recorder

Figure 3. Example of single radar waveform and resulting radar record (GSSI).

Depth of penetration is highly site-specific, being dependent upon the properties of the site's soil and rock. The method is limited in depth by attenuation, primarily due to the higher electrical conductivity of subsurface materials. Generally, better overall penetration is achieved in dry, sandy soils or rocky areas: poorer results are obtained in moist, clayey or conductive soils. However, many times data can be obtained from a considerable depth in saturated materials, if the specific conductance of the pore fluid is sufficiently low. Radar penetration from several to 100 feet is common.

The continuous data produced by the radar method offers a number of advantages over some other geophysical methods. Continuous profiling permits data to be gathered much more rapidly, thereby providing a large amount of data for a given budget. In some cases, total site coverage of an area can be obtained. Radar data may be obtained at speeds up to 5 to 10 miles per hour (mph) or more. Very high lateral resolution can be obtained by towing the antenna(s) by hand at much slower speeds (less than 1 mph). Radar has the highest resolution of all the surface geophysical methods on land. Vertical resolution of radar data can range from less than an inch to several feet depending upon the depth and the electromagnetic frequency used. A variety of antennas can be selected to cover frequencies from 12 MHz to 2,500 MHz. Lower frequencies provide greater depths of penetration, but lower resolution, and higher frequencies provide less penetration, but higher resolution (Benson and others, 1983).

2.2 Data Collection Procedures

The radar survey at the Southeast Rockford Ground Water Contamination site was conducted using a SIR 8 GPR system manufactured by Geophysical Survey Systems, Inc. (GSSI) of North Salem, New Hampshire. The survey was conducted on May 26-27, 1992 using a GSSI Model 3112 antenna operating at a center frequency of 80 MHz.

A total of thirtyfive (35) lines were run at the site (Table 1 and Figure 4). All radar lines were recorded with a range gain setting of 100 ns, a sensitivity of 100, and a high filter setting. The survey procedure consisted of towing the antenna behind a 4-wheel drive all-terrain vehicle (ATV) along the transect line. Data was directly recorded in the field on a graphic recorder as well as on a magnetic tape recorder. A gasoline generator and a power converter was used to provide power (12 v DC) to the system).

Distances along the transect were automatically measured and encoded as reference marks on the radar data by a Transwave Model NR1203 distance measuring instrument (DMI) at 10 foot distance intervals. The DMI detects pulses from a transducer installed on the vehicle speedometer cable and converts these pulses into distance measurements. Distance marks were placed every 10 feet on the radar records.

Table 1. GPR Lines.

Line #	From Grid Point	To Grid Point
1	50N 400E	350N 400E
2	350N 375E	50N 375E
3	50N 350E	250N 350E
4	250N 325E	50N 325E
5	50N 300E	350N 300E
6	50N 275E	350N 275E
7	350N 250E	50N 250E
8	50N 225E	350N 225E
9	350N 200E	50N 200E
10	50N 175E	350N 175E
11	350N 150E	50N 150E
12	50N 125E	400N 125E
13	400N 100E	0N 100E
14	0N 75E	450N 75E
15	450N 50E	0N 50E

16	50N 25E	450N 25E
17	450N 0E	50N 0E
18	50N 50E	50N 500E
19	0N 500E	0N 50E
20	100N 0E	100N 400E
21	150N 400E	150N 0E
22	200N 0E	200N 400E
23	250N 500E	250N 25W
24	300N 25W	300N 300E
25	350N 500E	350N 25W
26	400N 25W	400N 500E
27	450N 450E	450N 25W
28	475N 25W	475N 150E
29	400N 500E	0N 500E
30	50S 450E	50S 550E
31	50N 550E	50S 550E
32	50S 475E	350N 475E

33	200N 450E	400N 450E
34	600N 400E	600N 25W
35	600N 25W	50N 25W

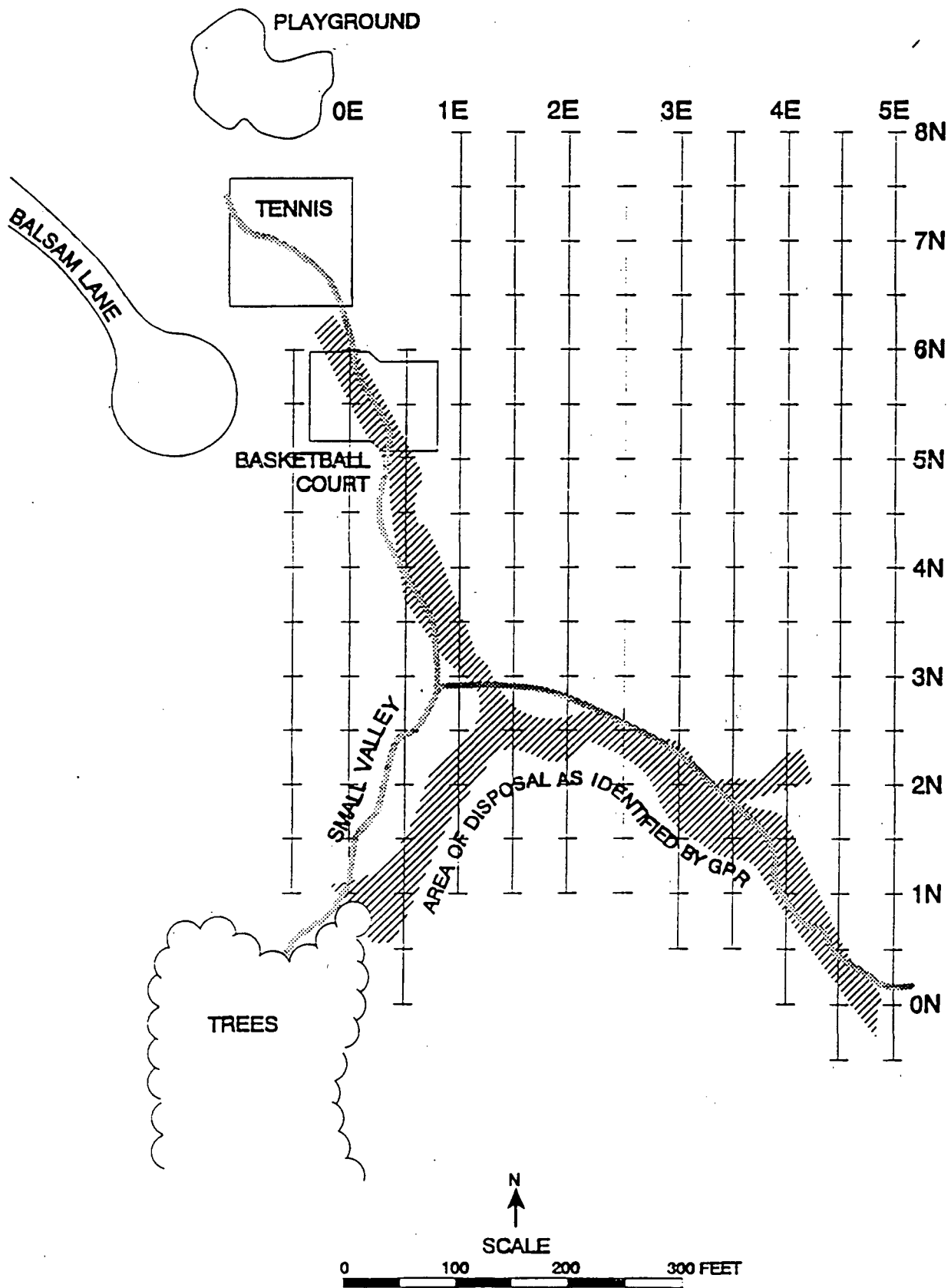


FIGURE 4 MAP SHOWING LOCATION OF GRID USED IN GPR SURVEY
AND LOCATION OF DISPOSAL AREAS AS DETERMINED BY GPR

The radar survey was conducted by Mark Vendl, Technical Support Section, Office of Superfund, Region V, U.S. EPA.

3.0 DATA INTERPRETATION AND RESULTS

Identification of significant anomalies on a GPR record is a pattern recognition process that consists of recognizing features on the records that are characteristic of known signatures. Identifiable features on a radar record fall into three main categories (Daniels, 1990):

- 1) Continuous reflections from horizontally layered horizons.
- 2) Reflections from two and three dimensional objects.
- 3) Lateral discontinuities that cause an abrupt change in the signal amplitude, diffractions, or a termination of adjacent reflections.

Based on the preliminary EM-31 data collected previously at the site, the waste material at this site was buried in long thin trenches. These features would then fall into category three above. One of the most common examples of lateral discontinuities is caused by a trench or excavation. Any trench or excavation dug in the ground would disturb the well defined layers of the natural undisturbed soil. When the excavation is filled in, the fill material becomes randomly mixed thus creating a disruption in the local stratigraphy. The presence of a point target within disturbed soil almost certainly indicates a buried, man-made object. Figure 5 is a radar

Pit boundaries

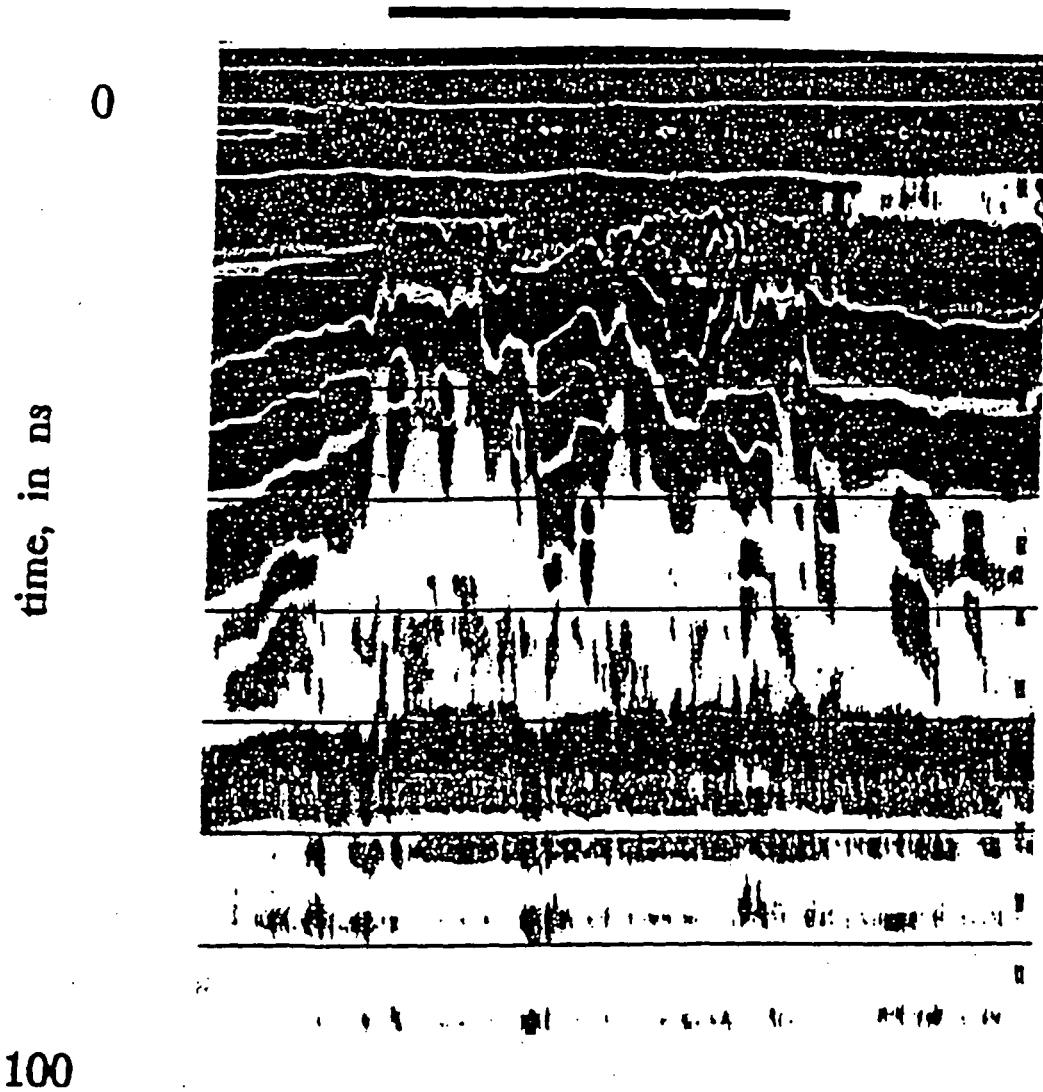


Figure 5. Radar record showing buried pit with several containers in close proximity (Daniels, 1990).

record which shows a buried pit with several containers in close proximity.

Figure 6 is a representative radar record from Area 7. It shows the same characteristics of a pit or trench filled with waste as is shown in the example in Figure 5. It shows the typical disruption of the "normal" radar signature and the presence of some point targets. Figure 4 shows the area of waste disposal as interpreted on the radar records. These areas correspond very well to the areas that were interpreted to have buried metal using the EM-31 during the reconnaissance survey.

GPR data is a time-based record. Vertical displacement on the graphic display is linear with time in a uniform media. The deeper the object, the longer it takes the radar pulse to travel from the radar transmitter to the object and return back to the radar receiver. Longer time intervals therefore show as being deeper in depth on the display. The time that it takes a radar pulse to travel down to a reflecting layer and return back to the surface is a measure of the depth of the reflecting layer.

In order to convert a time section to a depth section, it is necessary to determine the propagation velocity of the electromagnetic pulses. The relative dielectric permittivity of the material (ϵ_r) through which the electromagnetic pulse travels determines the propagation velocity according to the formula:

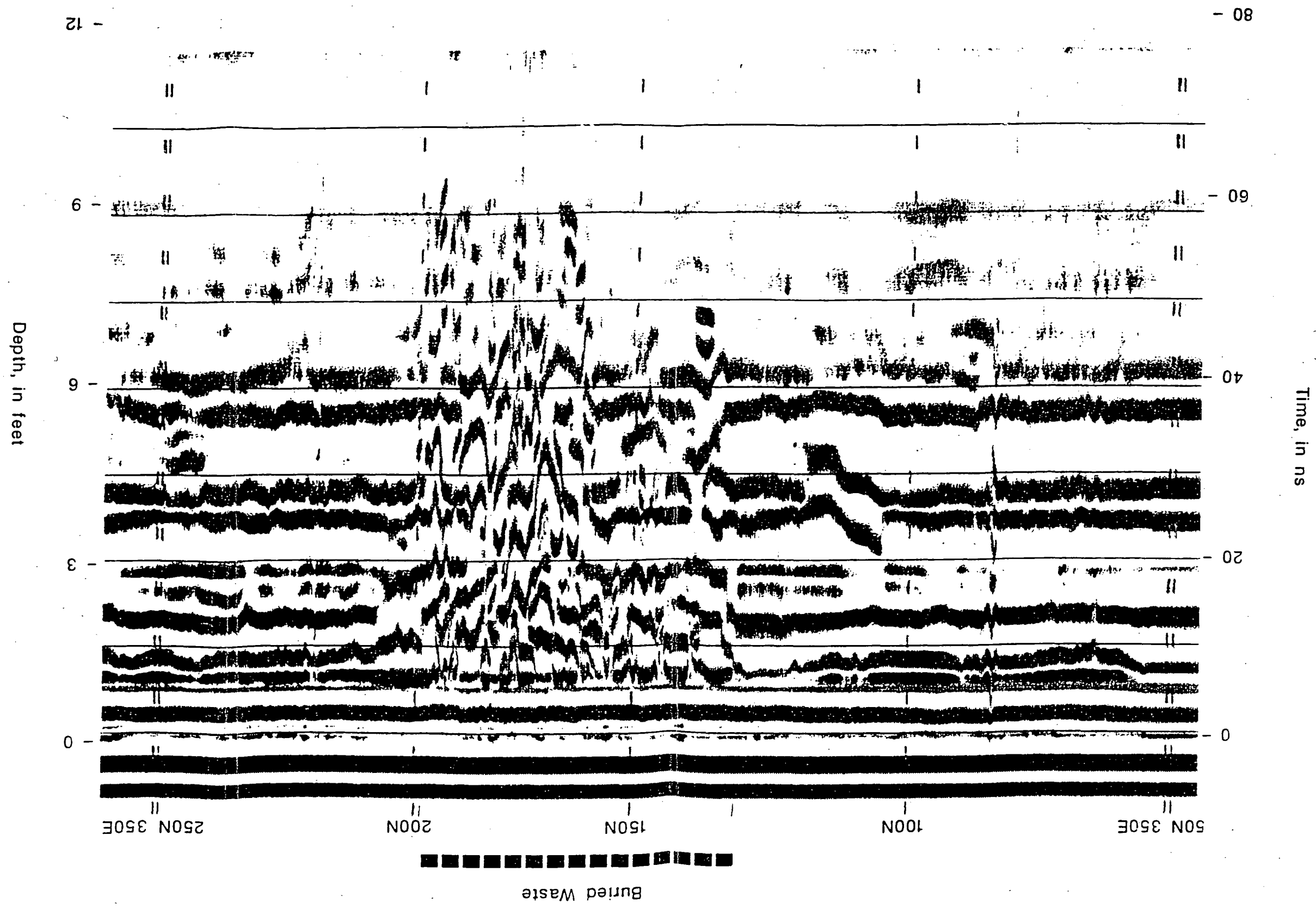


Figure 6. Representative Radar Record From Area 7.

$$V_m = \frac{c}{\sqrt{E_r}}$$

where c = propagation velocity in free space (3×10^8 m/sec = 1 ft/nanosecond) and
 V_m = propagation velocity through the material.

The relative dielectric permittivity was measured at a couple of locations (50N,100E and 50N,400E) using a VSP-915 Earth Constitutive Parameter Probe manufactured by Vadose Exploration, Inc. The VSP-915 consists of a reflecto-meter with digital LCD meters that display the complex values of soil reflection coefficients and a measurement probe that is inserted directly into the soil. The meter values are entered into equations to retrieve conductivity and the permittivity of the tested soil. The VSP-915 can take measurements at two different frequencies, 40 MHz and 60 MHz. Measurements at this site were taken in a pre-drilled 1.25 inch hole at a depth of one foot.

An average relative dielectric permittivity of 10 was calculated using the VSP-915. Using this value in the above equation give a propagation velocity through the subsurface material of 0.1 ft/ns. This value was used to generate the depth scale on the radar records. It should be remembered that a radar velocity is only valid at the point where that velocity has actually been measured. Extrapolation beyond the point of measurement, or interpolation between two or more measurement points, should be done with caution since subtle changes in moisture and soil/rock properties

can easily cause significant changes in velocity (travel time).

It is obvious from the radar records that waste fill begins right at or just below the ground surface. It is difficult to determine the thickness of the fill due to the amount of metal present. Metal effectively reflects 100% of the electromagnetic wave hitting, thus obscuring objects underneath.

4.0 CONCLUSIONS

The ground penetrating radar survey conducted at Area 7 was very successful in mapping the waste fill areas at this site. The waste appears to start right at or just beneath the ground surface.

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Daniels, J.J., 1990, Short course, fundamentals of ground penetrating radar: SoftEarth Associates Inc., Westerville, Ohio, 188 p.

Appendix B

Soil Gas Survey Report

by:

Tracer Research Corporation

Tracer Research Corporation

Shallow Soil Gas
Investigation

SOUTHEAST ROCKFORD

Rockford, Illinois
May 26-29, 1992

Tucson, Arizona

Franklin Park, New Jersey

Emeryville, California

Brussels, Belgium

San Antonio, Texas



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Shallow Soil Gas
Investigation

SOUTHEAST ROCKFORD

Rockford, Illinois
May 26-29, 1992

Submitted by:

Maigrip D. Stivers
C. Wesley P.

1-92-412-S



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1.0 SOUTHEAST ROCKFORD INVESTIGATION

Tracer Research Corporation (Tracer Research) performed a shallow soil gas investigation at a site in southeast Rockford, Illinois. The investigation was conducted May 26 through 29, 1992, for Camp, Dresser & McKee, Inc.

1.1 Objective

The purpose of the investigation was to assess the site for soil and groundwater contamination by screening shallow soil gas for the presence of volatile organic chemicals (VOCs). Soil gas samples were collected and analyzed for the following halocarbons.

1,1,1-trichloroethane (TCA)

trichloroethene (TCE)

tetrachloroethene (PCE)

1.2 Overview of Results

For this investigation, 78 soil gas samples were collected at depths of 1.5 to 7 feet below grade from 78 locations. TCA and PCE were found throughout the site. TCA was detected in 77 of the 78 samples in concentrations ranging from 0.002 to 3,800 micrograms per liter (ug/L). PCE was detected in 72 of the 78 samples in concentrations ranging from 0.0004 to 1,100 ug/L.

TCE was found in more than half of the samples collected in concentrations ranging from 0.0006 to 690 ug/L. The sample with the highest concentrations of each of the target compounds was SG-68.

2.0 SITE DESCRIPTION

The subsurface of the site is soil overlying fine-grained limestone bedrock. The depth to groundwater is 22 feet below grade. Groundwater flow is to the west, northwest.

3.0 SAMPLING PARAMETERS

Soil gas sampling probes consisted of 7-foot lengths of 3/4-inch diameter hollow steel pipe. The probes were fitted with detachable drive tips and pushed and pounded to depths of 1.5 to 7 feet below ground surface (bgs). The probes at sample locations SG-4 and SG-5 met refusal at 1.5 feet bgs. Probes at locations SG-25, SG-24, SG-3, and SG-10 met



refusal at depths ranging from 1.5 to 3.5 feet bgs. SG-8 and SG-9 probes met refusal at 5 feet bgs.

The aboveground end of each probe was fitted with an aluminum reducer (manifold) and a length of polyethylene tubing leading to a vacuum pump. Soil gas was pulled by the vacuum pump into the probe. Samples were collected in a glass syringe by inserting a syringe needle through a silicone rubber segment in the evacuation line and down into the steel probe. The vacuum was monitored by a vacuum gauge to ensure an adequate gas flow from the vadose zone was maintained.

The volume of air within the probe was purged by evacuating 2 to 5 probe volumes of gas. The evacuation time in minutes versus the vacuum in inches of mercury (Hg) was used to calculate the necessary evacuation time. The vacuum in inches Hg was recorded at each sampling location.

Sample probe vacuums ranged from 2 to 10 inches Hg. The vacuum capacity of the pump was approximately 20 inches Hg.

Wet clay and mud were seen on probes retracted from sampling locations SG-22, SG-26, SG-29, SG-30, SG-34, SG-47, and SG-58. The mud and clay observed on the probe retracted from SG-34 was an organic peat color. Also, a slight to strong odor was detected in Samples SG-11, SG-34, and SG-47.

4.0 ANALYTICAL PARAMETERS

During this investigation, 6 to 10 milliliters (mL) of soil gas were collected for each sample and immediately analyzed in the Tracer Research analytical van. Subsamples (replicates) from these samples were injected into the gas chromatograph (GC) in volumes of 0.01 to 500 microliters (uL) Several of these subsamples were diluted because they contained high concentrations of the targeted VOCs.



4.1 Analyte Class

The soil gas samples were analyzed for the following analyte class and compounds:

Analyte Class: Halocarbon

1,1,1-trichloroethane (TCA)

trichlorethene (TCE)

tetrachloroethene (PCE)

4.2 Chromatographic System

A Varian 3300 gas chromatograph, equipped with an electron capture detector (ECD) and a computing integrator, was used for the soil gas analyses. Compounds were separated in the GC on a 6 foot by 1/8 inch outer diameter (OD) packed analytical column (10% OV101 stationary phase bonded to 80/100 mesh Chromosorb W support) in a temperature controlled oven. Nitrogen was used as the carrier gas.

The instrument calibrations were checked periodically throughout each day to monitor the response factor and retention time. The following paragraphs explain the GC and ECD processes.

GC Process

The soil gas vapor is injected into the GC where it is swept through the analytical column by the carrier gas. The detector senses the presence of a component different from the carrier gas and converts that information to an electrical signal. The components of the sample pass through the column at different rates, according to their individual properties, and are detected by the detector. Compounds are identified by the time it takes them to pass through the column (retention time).

ECD Process

The ECD captures low energy thermal electrons that have been ionized by beta particles. The flow of these captured electrons into an electrode produces a small current, which is collected and measured. When the halogen atoms (halocarbons) are introduced into the detector, electrons that would otherwise be collected at the electrode are captured by the sample, resulting in decreased current. The current causes the computing integrator to



record a peak on a chromatogram. The area of the peak is compared to the peak generated by a known standard to determine the concentration of the analyte.

4.3 Analyses

The detection limits for target compounds depend on the sensitivity of the detector to the individual compound as well as the volume of the injection. The detection limits of the target compounds were calculated from the response factor, the sample size, and the calculated minimum peak size (area) observed under the conditions of the analyses. If any compound was not detected in an analysis, the detection limit is given as a "less than" value, e.g., <0.1 ug/L. The approximate detection limits for the target compounds are presented in the below.

Table 1. Detection Limits for Soil Gas Compounds

Compound	Detection Limits (ug/L)
TCA	0.0002
TCE	0.0001
PCE	0.0003

5.0 QUALITY ASSURANCE AND QUALITY CONTROL

Tracer Research's Quality Assurance (QA) and Quality Control (QC) program was followed to maintain data that was reproducible through the investigation. An overview presenting the significant aspects of this program is presented below.

Soil Gas Sampling Quality Assurance

To ensure consistent collection of soil gas samples, the following procedures are performed:



- Sampling Manifolds

Tracer Research's custom designed sampling manifold connects the sample probe to the vacuum line and pump. The manifold is designed to eliminate sample exposure to the polymeric (plastic) materials that connect the probe to the vacuum pump.

The sampling manifold is attached to the end of the probe, forming an air tight union between the probe and the silicone tubing septum. The septum connects the manifold to the pump vacuum line and permits syringe sampling.

This sampling system allows the sample to be taken upstream of the sampling pump, manifold, and septum. Since cross contamination of sampling equipment can be a major problem, Tracer Research replaces the materials (probe and syringe), between sampling points, that contact the soil gas before or during sampling.

-Sampling Probes

Steel probes are used only once each day. To eliminate the possibility of cross contamination, they are washed with high pressure soap and hot water spray, or steam-cleaned. Enough sampling probes are carried on each van to avoid the need to re-use any during the day.

-Glass Syringes

Glass syringes are used for only one sample a day and are washed and baked out at night. If they must be used twice, they are purged with carrier gas (nitrogen) and baked out between probe samplings.

-Sampling Efficiency

Soil gas pumping is monitored by a vacuum gauge to ensure that an adequate flow of gas from the soil is maintained. A reliable gas sample can be obtained if the sample vacuum gauge reading is at least 2 inches Hg less than the maximum measured vacuum of the vacuum pump.

Analytical Quality Assurance Samples

Quality assurance samples are performed at the below listed, or greater, frequencies. The frequency depends on the number of soil gas samples analyzed and the length of time of the survey:



Table 2. Quality Assurance Samples

Sample type	Frequency
Ambient Air Samples	2 per day or per site
Analytical Method Blanks	5% (1 per 20 samples or 1 a day)
Continuing Calibration Check	20% (1 every 5 samples)
Field System Blank	10% (1 every 10 samples or 1 a day)
Reagent Blank	1 per set of working standards
Replicate Samples	100% of all soil gas samples

The ambient air samples are obtained on site by sampling the air immediately outside the mobile analytical van and directly injecting it into the GC. Analytical method blanks are taken to demonstrate that the analytical instrumentation is not contaminated. These are performed by injecting carrier gas (nitrogen) into the GC with the sampling syringe. Subsampling syringes are also checked in this fashion.

The injector port septa through which soil gas samples are injected into the GC are replaced daily to prevent possible gas leaks from the chromatographic column. All sampling and subsampling syringes are decontaminated after use and are not used again until they have been decontaminated by washing in anionic detergent and baking at 90°C.

Field system blanks are analyzed to check for contamination of the sampling apparatus, e.g., probe and sampling syringe. A sample is collected using standard soil gas sampling procedures, but without putting the probe into the ground. The results are compared to those obtained from a concurrently sampled ambient air analysis.

If the blanks detect compounds of interest at concentrations that indicate equipment contamination or concentrations that exceed normal background levels (ambient air



analysis), corrective actions are performed. If the problem cannot be corrected, an out-of-control event is documented and reported.

A reagent blank is performed to ensure the solvent used to dilute the stock standards is not contaminated. Analytical instruments are calibrated daily using fresh working standards made from National Institute of Sciences and Technology traceable standards and reagent blanked solvents.

Quantitative precision is assured by replicating analysis of 100 percent of the soil gas samples. Replicate analyses are performed by subsampling vapors from the original sampling syringe.

6.0 RESULTS

The analytical results from this soil gas investigation are condensed in Appendix A. The data are presented by location and by analyte concentration. When the compound was not detected, the detection limit is presented as a "less than" value, e.g., <0.0001 ug/L. A map of the sampling locations is included in Appendix B.

Soil gas samples are identified by sample location and sampling depth. For example, SG-1-5' represents soil gas sample number one, collected at a depth of 5 feet below the ground surface. A summary of the soil gas investigation is presented in the table below.

Table 3. Soil Gas Sample Summary

Compound	# of samples in which compound was detected	Low conc. ug/L	High conc. ug/L	Sample(s) with high conc.
TCA	77	0.002	3,800	SG-68
TCE	41	0.0006	690	SG-68
PCE	72	0.004	1,100	SG-68



TCA is found throughout the site (Figure 2). The contamination extends from an area north of the tennis courts south through the disposal area, and northeast through the gravel pit area. Samples SG-68 (3,800 ug/L) and SG-36 (1,700 ug/L) form an anchor of the contamination.

Sample SG-62 (2,800 ug/L), near the basketball court, is also an area of high concentrations of TCA. These two areas are approximately 300 feet apart and do not appear to be related. A region of low concentrations surrounded by higher concentrations is found in the old gravel pit area.

Sample SG-68 contained the greatest amount of TCE (690 ug/L) found at this site (Figure 3). The contamination extends from an area east of the tennis court south through the disposal area. The contamination seems to follow the natural drainage pathways of the area.

High concentrations of PCE are found to the south of the basketball court at this site (Figure 4). Sample SG-68 (1,100 ug/L) forms the anchor of the contamination. Contamination extends from an area north of the tennis courts to the south and east through a disposal area.

The anchors of the contamination for all three target VOCs are found at Samples SG-62 and SG-68. All three compounds have similar contour outlines and seem to follow the natural drainage pathways in the area. More samples need to be taken on the north, west, and south sides of the site to better define the extent of the contamination.



APPENDIX A Condensed Data

TRACER RESEARCH CORPORATION - ANALYTICAL RESULTS
CAMP DRESSER & MCKEE/SOUTHEAST ROCKFORD /ROCKFORD, ILLINOIS/ JOB#1-92-412-S
05/26/92

SAMPLE	TCA ug/l	TCE ug/l	PCE ug/l
AIR	0.0005	<0.0001	0.00006
SG-1-7'	0.06	0.0006	0.06
SG-2-7'	0.09	0.001	0.1
SG-3-3.5'	0.002	0.0007	0.02
SG-4-1.5'	0.2	0.05	8
SG-5-1.5'	1	0.001	0.8
SG-6-7'	0.2	<0.0006	0.1
SG-7-7'	0.2	<0.0006	0.06
SG-8-5.5'	0.003	<0.0006	0.001
SG-9-5'	0.005	0.002	0.001
AIR	0.0006	<0.004	0.00007
SG-10-3.5'	0.01	0.006	0.002

Analyzed by: E. Kaupanger

Proofed by: M. Stivers



TRACER RESEARCH CORPORATION - ANALYTICAL RESULTS
CAMP DRESSER & MCKEE/ SOUTHEAST ROCKFORD/ ROCKFORD, ILLINOIS/ JOB#1-92-214-S
05/26/92

SAMPLE	TCA ug/l	TCE ug/l	PCE ug/l
SG-11-3.5'	0.8	<0.0006	0.08
SG-12-3.5'	0.02	<0.0006	0.0007
SG-13-5.5'	2	<0.0006	0.5
SG-14-7'	0.4	0.02	0.4
SG-15-7'	2	0.7	21
SG-16-7'	0.7	0.05	0.3
SG-17-3.5'	0.003	<0.0006	0.001
SG-18-7'	6	7	22
SG-19-7'	35	3	7
SG-20-5'	0.07	<0.0006	0.02
AIR	0.004	<0.0001	<0.00006

Analyzed by: E. Kaupanger

Proofed by: W. Stivers



TRACER RESEARCH CORPORATION - ANALYTICAL RESULTS
 CAMP DRESSER & MCKEE/SOUTHEAST ROCKFORD /ROCKFORD, ILLINOIS/JOB#1-92-214-S
 05/27/92

SAMPLE	TCA ug/l	TCE ug/l	PCE ug/l
AIR	0.008	0.0004	0.0008
SG-21-6.5'	0.006	<0.0006	0.02
SG-22-6'	0.9	<0.0006	0.02
SG-23-7'	0.02	<0.0006	0.0004
SG-24-3'	0.002	<0.0006	0.0005
SG-25-2.5'	0.004	<0.0006	0.0004
SG-26-7'	0.003	<0.0006	0.004
SG-27-7'	4	0.4	2
SG-28-3.5'	0.02	0.004	0.01
SG-29-7'	0.9	0.02	0.4
SG-30-7'	56	6	10
SG-31-5'	1	0.08	0.3
SG-32-7'	0.01	<0.0006	0.003
AIR	0.001	<0.001	0.0006
SG-33-7'	0.4	0.008	0.6
SG-34-7'	950	180	64
SG-35-7'	0.3	0.03	0.03
SG-36-7'	1700	130	470
SG-37-7'	210	1	16
SG-38-7'	390	26	98

Analyzed by: E. Kaupanger

Proofed by: m. Stivers



TRACER RESEARCH CORPORATION - ANALYTICAL RESULTS
CAMP DRESSER & MCKEE/SOUTHEAST ROCKFORD /ROCKFORD, ILLINOIS/JOB#1-92-214-S
05/27/92

SAMPLE	TCA ug/l	TCE ug/l	PCE ug/l
AIR	0.008	0.0004	0.0008
SG-39-6'	200	55	28
SG-40-7'	4	<0.01	0.3
AIR	0.001	<0.0001	0.0001
SG-41-7'	0.004	<0.0006	0.001
SG-42-7'	230	34	220

Analyzed by: E. Kaupanger

Proofed by: M. Stevens



TRACER RESEARCH CORPORATION - ANALYTICAL RESULTS
 CAMP DRESSER & MCKEE /SOUTHEAST ROCKFORD /ROCKFORD, ILLINOIS /JOB#1-92-214-S
 05/28/92

SAMPLE	TCA ug/l	TCE ug/l	PCE ug/l
AIR	0.02	0.002	0.001
SG-43-7'	0.007	0.002	0.01
SG-44-7'	0.006	0.0009	0.0007
SG-45-7'	0.003	0.002	0.002
SG-46-7'	0.009	0.001	0.004
SG-47-7'	0.01	<0.0006	<0.0003
SG-48-7'	0.02	<0.0006	<0.0003
SG-49-7'	0.007	0.004	0.02
SG-50-7'	0.06	0.02	0.08
SG-51-7'	<0.0002	<0.0006	<0.0003
SG-52-7'	0.006	<0.0001	0.004
SG-53-7'	0.006	<0.0001	0.003
SG-54-7'	0.01	<0.0001	0.005
SG-55-7'	0.8	0.02	1
SG-56-7'	0.003	<0.0001	0.005
SG-57-7'	0.1	<0.0006	0.6
AIR	0.0008	<0.0001	<0.00006
SG-58-7'	0.002	<0.0001	0.0008
SG-59-7'	0.04	<0.0001	0.003

Analyzed by: E. Kaupanger

Reviewed by: M. Stevens



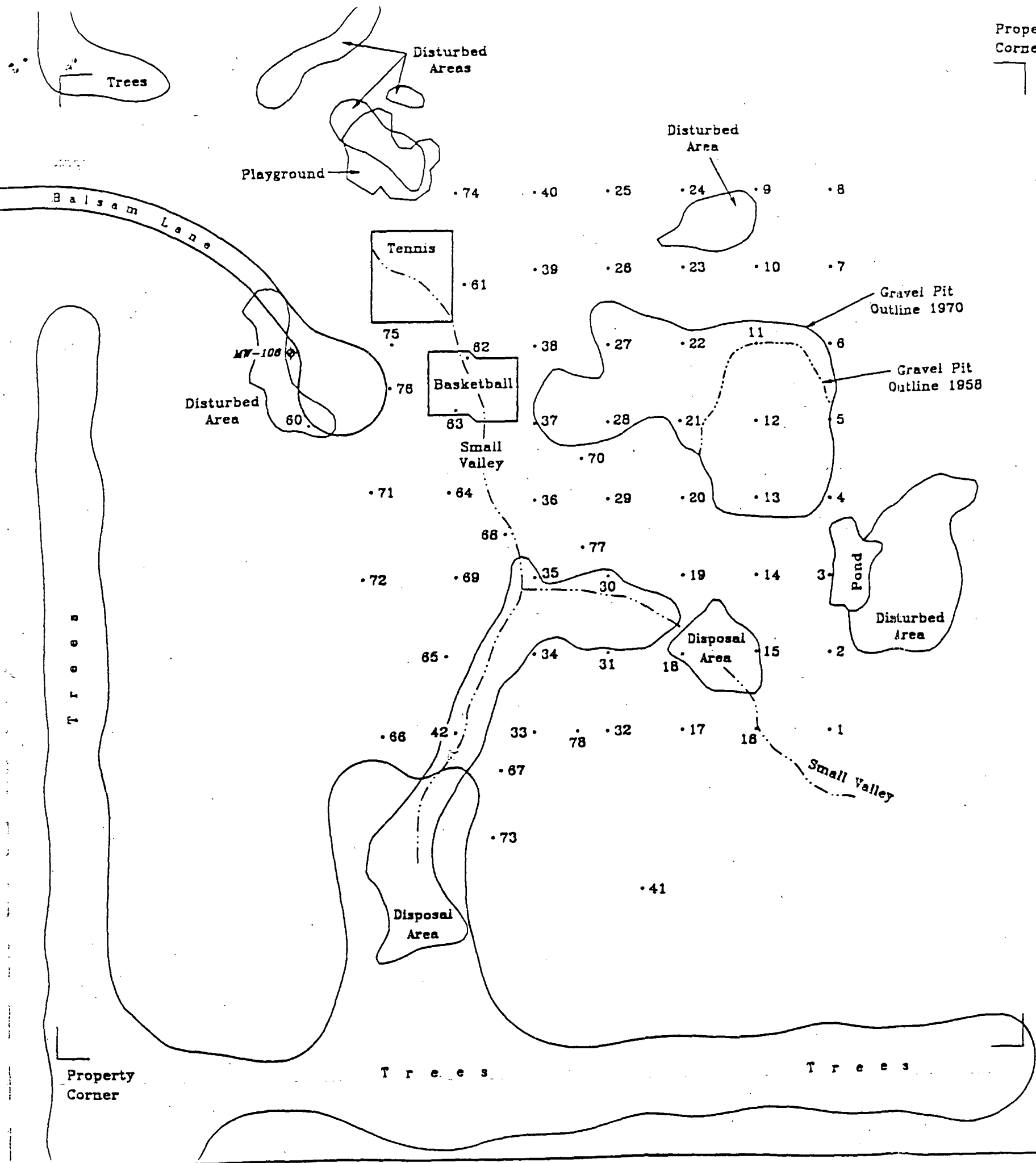
TRACER RESEARCH CORPORATION - ANALYTICAL RESULTS
CAMP DRESSER & MCKEE /SOUTHEAST ROCKFORD /ROCKFORD, ILLINOIS/JOB#1-92-412-S
05/28/92

SAMPLE	TCA ug/l	TCE ug/l	PCE ug/l
AIR	0.02	0.002	0.001
SG-60-7'	5	<0.01	0.06
SG-61-7'	160	<0.06	14
SG-62-7'	2800	64	980
SG-63-7'	17	<0.06	<0.03
SG-64-7'	440	120	160
SG-65-7'	0.0008	<0.0006	<0.0003
AIR	0.0002	<0.0001	<0.00005
SG-66-7'	2	<0.0006	0.3
SG-67-7'	170	48	500

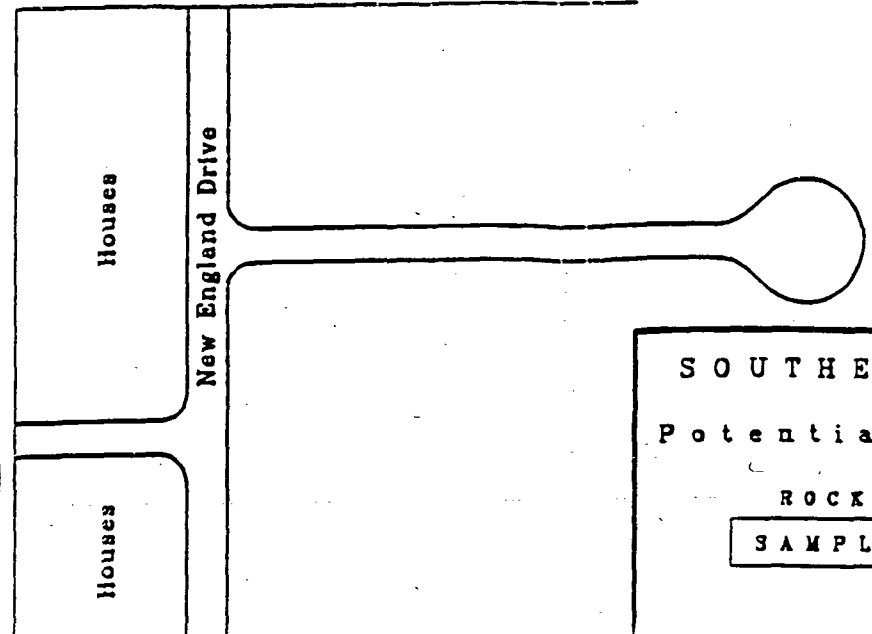
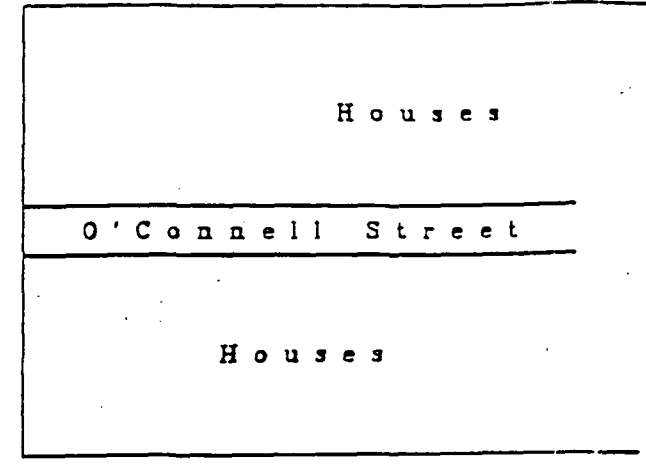
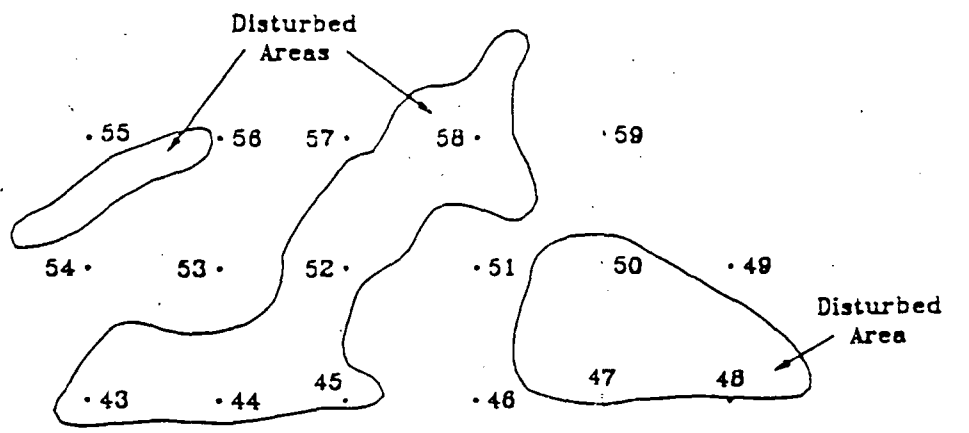
Analyzed by: E. Kaupanger

Proofed by: Mr. Stivers



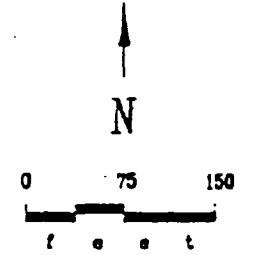


Property
Corner



EXPLANATION

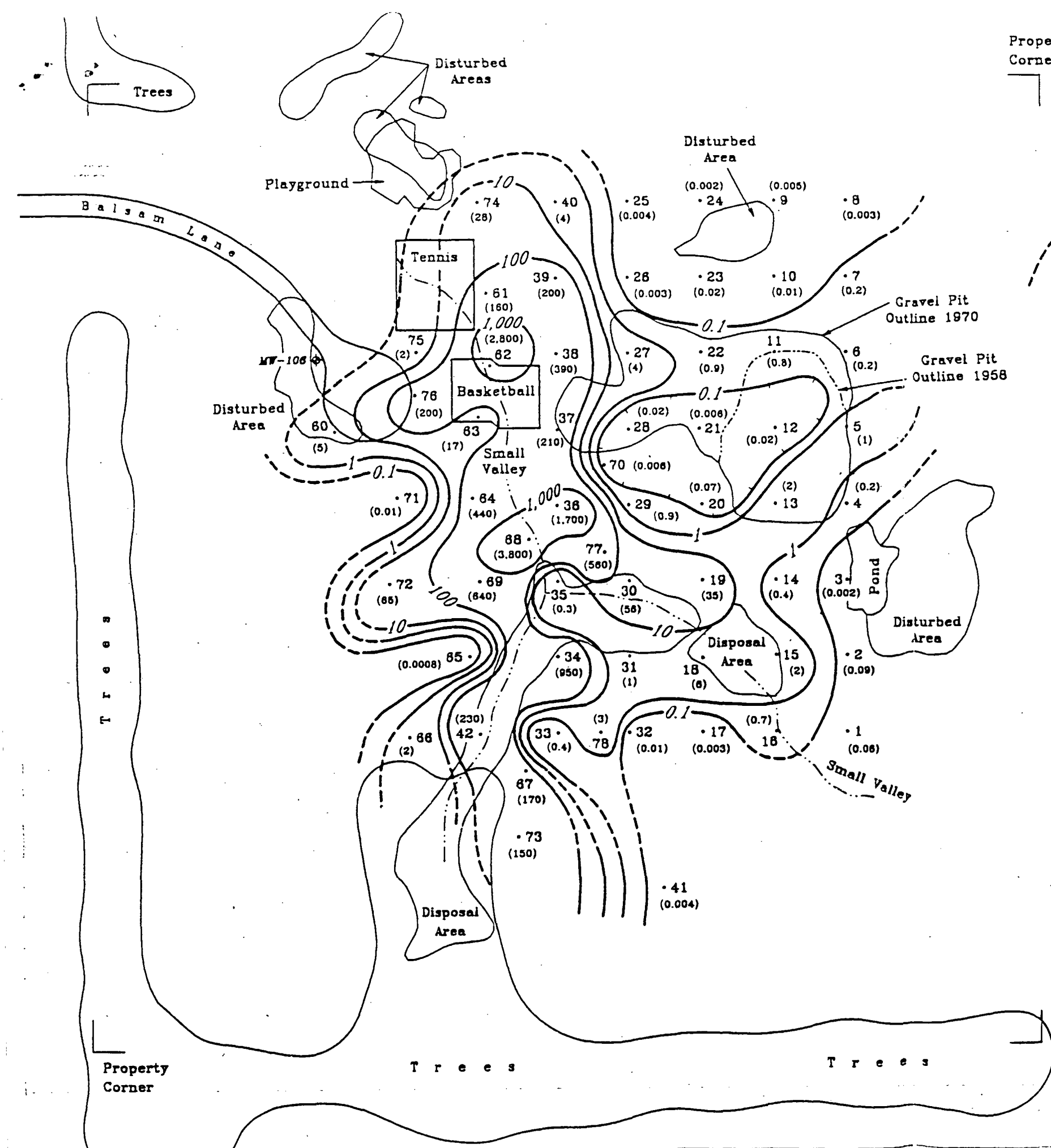
- 1 Sampling Probe Location
- ◆ MW-106 Monitoring Well Location



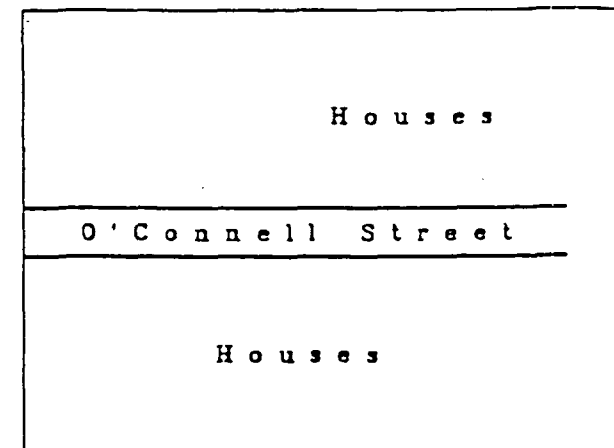
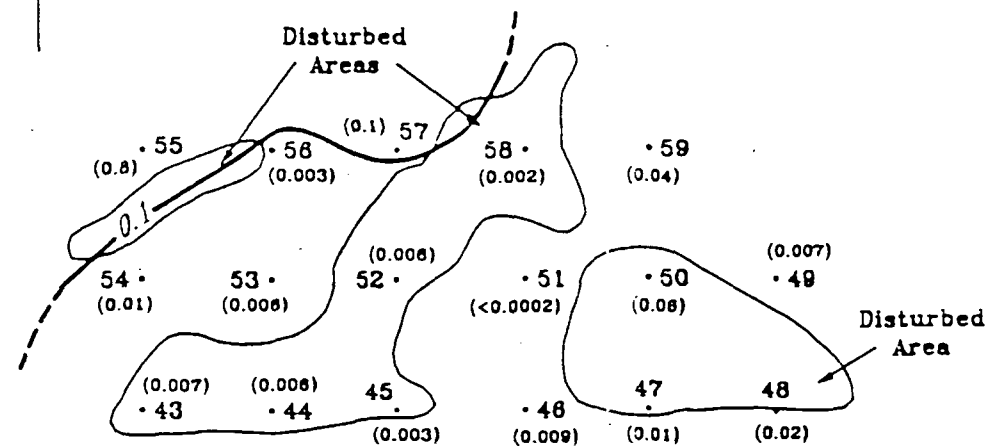
1-92-412-S

SOUTHEAST ROCKFORD
Potential Source Area 7
ROCKFORD, ILLINOIS
SAMPLING LOCATIONS

Figure 1

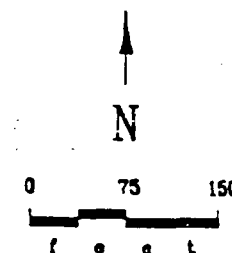


Property
Corner



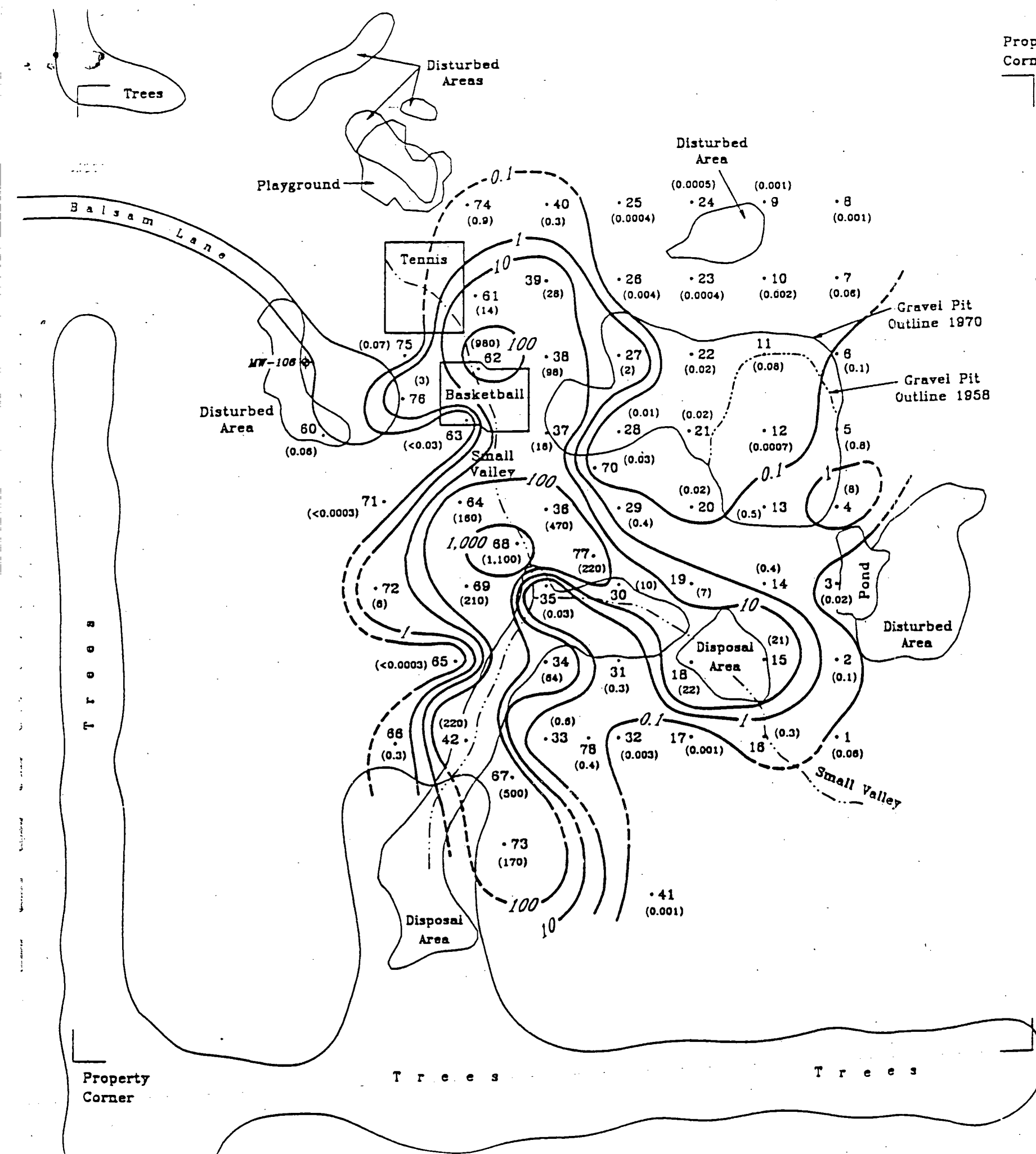
EXPLANATION

- 1 Sampling Probe Location
- ◆ MW-106 Monitoring Well Location
- (0.001) Soil Gas Sample Value (µg/l)
- 0.1 - Isoconcentration Line (µg/l)

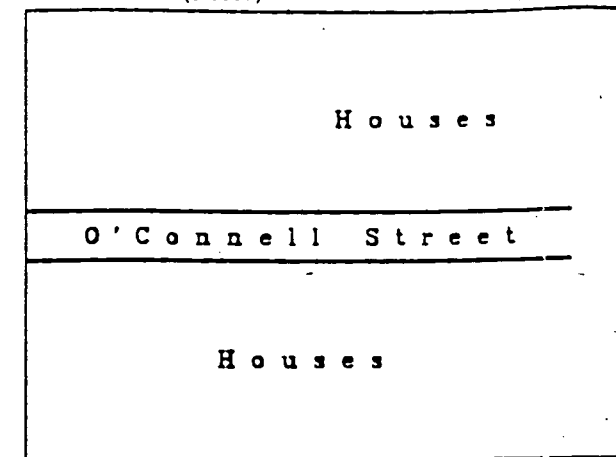
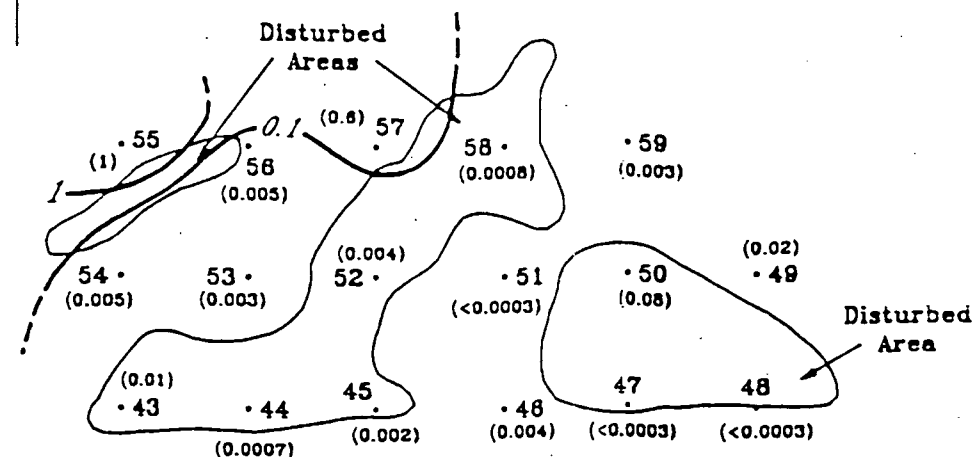


1-92-412-S

SOUTHEAST ROCKFORD
Potential Source Area 7
ROCKFORD, ILLINOIS
TRICHLOROETHANE (TCA)

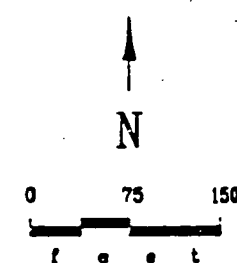


Property
Corner



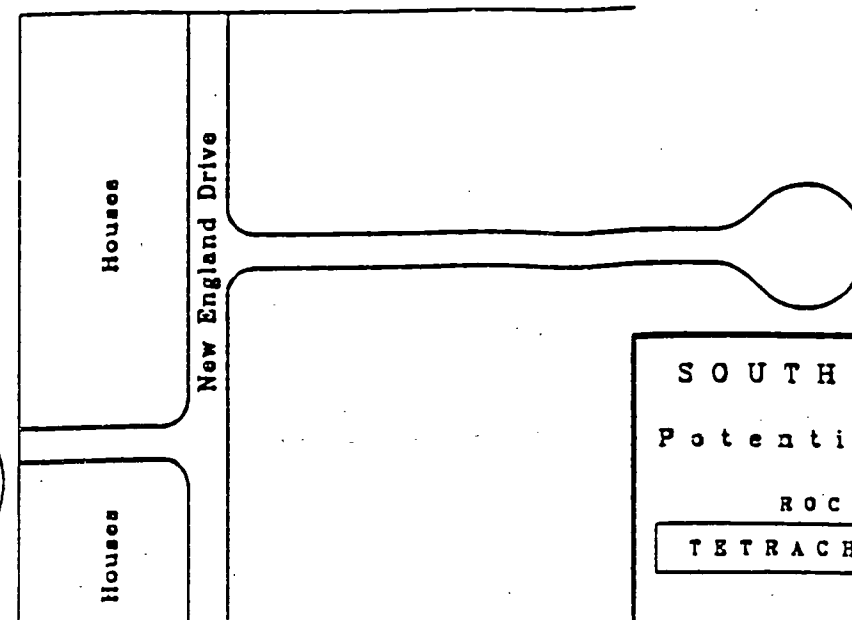
EXPLANATION

- 1 Sampling Probe Location
- ◆ MW-100 Monitoring Well Location
- (0.08) Soil Gas Sample Value (µg/l)
- 0.1 - Isoconcentration Line (µg/l)



1-92-412-S

SOUTHEAST ROCKFORD
Potential Source Area 7
ROCKFORD, ILLINOIS
TETRACHLOROETHENE (PCE)



Appendix C

Calculations Used to Derive Solvent Concentrations in Soil

$$C_s = \frac{C_g f_{oc} K_{oc} T R}{H}$$

For 1,1,1 TCA

$$C_{g, \max} = 3.8 \text{ mg/L (max for 1,1,1-TCA)}$$

$$f_{oc} \approx 0.005$$

$$K_{oc} = \log^{-1}(2.18) = 152 \text{ mL/g}$$

$$T = 283^\circ \text{K}$$

$$R = 8.2 \times 10^{-5} \text{ atm m}^3/\text{mol K}$$

$$H = 0.013 \text{ atm m}^3/\text{mol}$$

$$C_s = \frac{3.8 \text{ mg/L} \cdot 0.005 \cdot 152 \text{ L/kg} \cdot 283^\circ \text{K} \cdot 8.2 \times 10^{-5} \text{ atm m}^3/\text{mol}}{0.013 \text{ atm m}^3/\text{mol}}$$

$$C_s = 5.16 \text{ mg/kg} = 5.16 \text{ ppm}$$

For PCE

$$C_{g, \max} = 11 \text{ mg/L}$$

$$K_{oc} = 364 \text{ L/kg}$$

$$H = 0.0131 \text{ atm m}^3/\text{mol}$$

$$C_s = \frac{(1.1)(0.005)(364)(283)(8.2 \times 10^{-5})}{0.0131}$$

$$= 3.55 \text{ mg/kg}$$

For TCE

$$C_{g, \max} = 0.69 \text{ mg/L}$$

$$K_{oc} = 126$$

$$H = 0.0071$$

$$C_s = \frac{(0.69)(0.005)(126)(283)(8.2 \times 10^{-5})}{0.0071}$$

$$C_s = 1.42 \text{ mg/kg}$$

